ANALYSIS OF ARCHAEOLOGICAL SETTLEMENT PATTERNS IN GRASSLANDS NATIONAL PARK, SASKATCHEWAN

A Thesis Submitted to the College of

Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Arts

In the Department of Anthropology and Archaeology

University of Saskatchewan

Saskatoon

By

Nathan Paul Friesen

Fall 1998

Permission to Use

In presenting this thesis in partial fulfilment of the requirements for the degree of Master of Arts from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner for scholarly purposes, in whole or in part, may be granted by the professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College of Arts and Science. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis.

Requests for permission to copy or to make other use of material in this thesis in whole or part should be addressed to:

Head of the Department of Anthropology and Archaeology
55 Campus Drive
University of Saskatchewan
Saskatoon, Saskatchewan S7N 5B1

Abstract

The purpose of this study is to analyze archaeological settlement patterns within Grasslands National Park using Geographic Information Systems. Grasslands National Park is located in southwestern Saskatchewan along the international border and is split into West and East Blocks. The Park is primarily short grass prairie with the Frenchman River Valley running through the West Block and a system of north-south drainages running through the largely flatter grasslands of the East Block.

Archaeological data for this study are derived from the results of an extensive survey of Grasslands National Park which recorded over 3000 surface sites. In addition to the survey, digital environmental data on topography, vegetation and soils were obtained from the Park for the purposes of analysis. Remote sensing data were used to conduct additional mapping of water sources. Analysis consisted of a statistical comparison of site and feature type distributions over classes of environmental data. Statistically significant results were interpreted within the framework of the archaeological context of southwestern Saskatchewan.

The study found that specific feature types had particular relationships to topography and the environment. Sites with stone rings were often located in upland areas near seasonal water sources. An association between sites with stone rings and grasses which are preferred by bison for forage is particularly strong. As bison may have intensively occupied the Park area in the late spring to take advantage of late spring growth of some grasses, the Park may have been extensively used by people hunting bison in the spring and early summer. In general topography, distance from water, and vegetation type were all significant factors in the distribution of sites and feature types.

It is hoped that this thesis has provided a case study for the use of Geographic Information Systems within the archaeology of the Northern Plains. The large body of survey data along with access to numerous environmental data sets has provided an excellent opportunity to analyse settlement patterns within the Canadian plains.

Acknowledgments

I would like to thank my supervisor, Dr. Ernie Walker and the rest of my committee, Dr. Margaret Kennedy and Dr. Urve Linnamae, as well as my external advisor Dr. Lawrence Martz, for their support, suggestions and guidance. Their suggestions helped to insure that this thesis achieved its full potential.

Thanks are also due to Gary Adams of Canadian Heritage in Winnipeg for his help with the archaeological survey data. He helped to clarify and elaborate many important points. Pat Fargey at Grasslands National Park was very helpful with information on the Park and GIS data sources. His hospitality is also much appreciated. Lorie Wiesner devoted a day towards touring the East Block. Lorena Patino insured that primary GIS data were made available.

The Department of Geography at the University of Saskatchewan donated the use of their computers for initial work. Dr. Lawrence Martz assisted with useful suggestions on GIS methodology. Dr. David Meyer and Dale Russell suggested useful historical research sources. Elena Ponomarenko provided last minute information of the geological history of the Park.

Western Heritage Services Inc. and Digital Environmental Management Inc. both generously provided the use of their computing equipment and software. Melanie Harlow and John Polson provided their expertise in remote sensing. The Photographer's Gallery provided the use of a monitor at a critical period. The Saskatchewan Archaeological Society and Saskatchewan Lotteries Trust Fund for Sport, Culture & Recreation provided funding for part of this research.

Thanks also goes to my parents, Ralph and Hannah Friesen, who contributed their considerable editing skills. Thom Morely provided help with computer programming and Mike Magee also assisted with computing issues. D'Arcy Green provided essential moral support. Brenda Kramerchuk donated the use of her tent and printer. Jonah O'Neil helped with the details of the Park survey. Melanie Harlow and Jill Taylor-Hollings provided last minute advice.

Finally, my wife Liz read and commented on everything I wrote and supported me when I really needed it.

Table of Contents

List of Tables

List of Figures

1.0 The Environmental and Cultural Setting of Grasslands National Park

1.0.1 Origin of the Project

The idea for the analysis which became this thesis was first conceived of when the author became aware of the survey of Grasslands National Park (G.N.P.) being conducted by Gary Adams and Peter Filopoulos. The vast amount of data they were gathering about site location and site characteristics showed great potential for use in a Geographic Information System (GIS) research project. Discussions with Scott Hamilton of Lakehead University helped to clarify the initial stages of the analysis that could be conducted on the data from GNP. A very preliminary study illustrated the massive work of assembling a quality GIS dataset and pointed to the direction where a comprehensive analysis would have to go. The results of the continued research are presented in this thesis.

1.0.2 Aims of the Research

The general aim of this research is to provide a sophisticated analysis of settlement patterns on the Northwestern Plains with a specific emphasis on southwestern Saskatchewan. The intention is also to provide a GIS case study to help establish GIS as a part of the methodology used by Plains archaeologists. GIS settlement studies have been prominent in Britain, the Netherlands and other parts of Europe, and Australia. However, the use of GIS in North American archaeology has largely been in aid of cultural resource management studies with a focus on predictive modelling. It is hoped that the future use of GIS on the Plains will include further settlement studies. The often sparse nature of the archaeological record on the Plains has prompted archaeologists to develop various methodologies for obtaining the maximum amount of information from the record. This is evident in the advances of areas like faunal analysis, pollen analysis, geoarchaeology, lithic analysis and replicative studies, to name a few. The use of GIS has the potential to become another of these key methodologies.

1.1 Park Location and Environment

Grasslands National Park is located in southwestern Saskatchewan within the Northwestern Plains (Figure 1.1). The Frenchman River Valley runs through the West Block of the Park while the East Block is dominated by the Rock Creek drainage. Both of these drainages flow into the Milk River and ultimately into the Missouri River to the south.

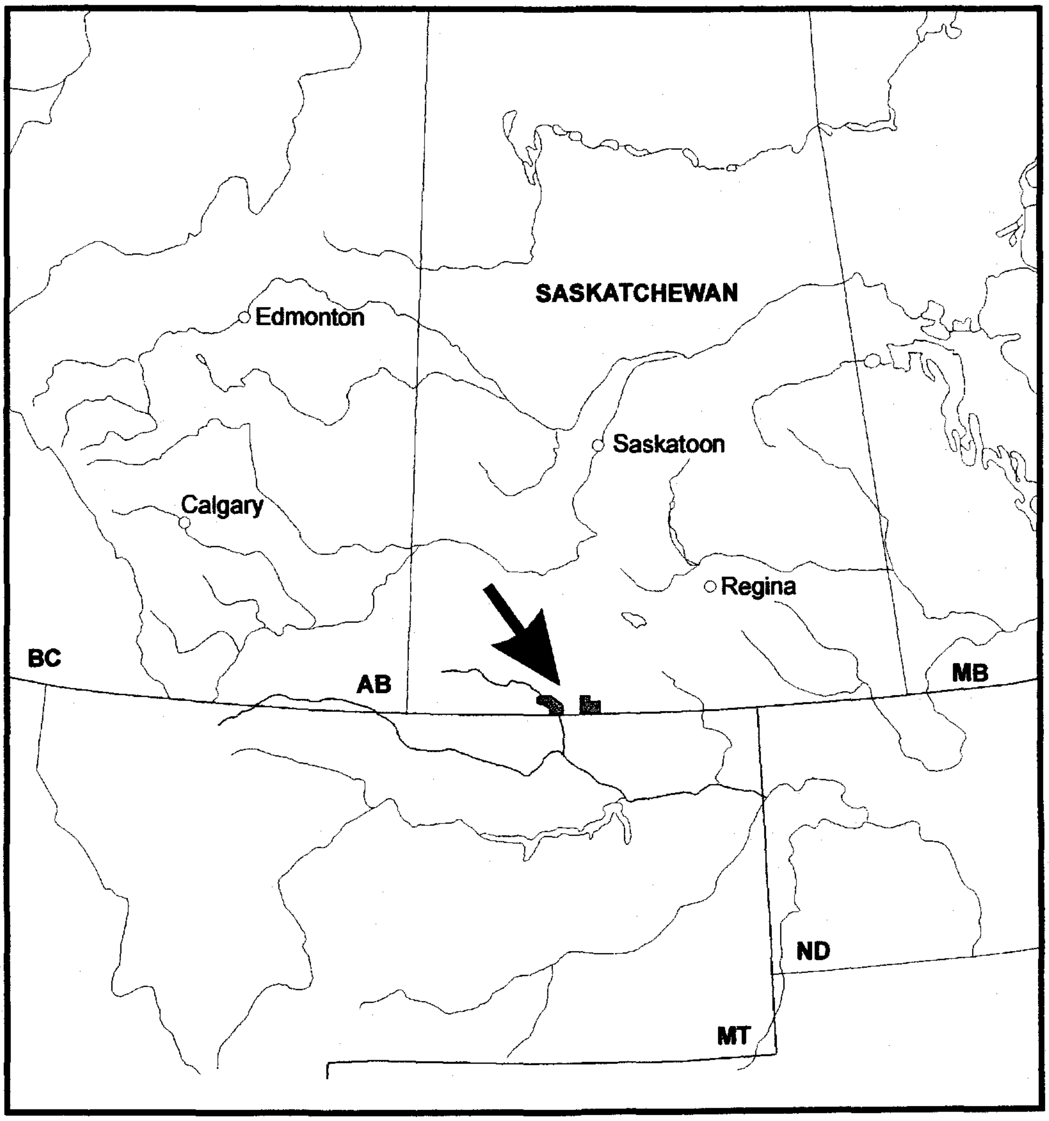

Figure 1.1 Location of Grasslands National Park Within the Northwestern Plains.

Landforms

The West Block (Figure 1.2) spans a stretch of the Frenchman River Valley from Val Marie to the international border. The valley bottom is almost flat. Brush types of vegetation are found along the Frenchman River which flows year-round (Figure 1.3). The north side of the valley is dominated by a system of coulees and drainages running mainly north-south with grassy upland areas in between (Figure 1.5). South of the valley, the landscape is hummocky with few defined drainages. The landscape is rolling with numerous intermittent sloughs and potholes (Figures 1.4 and 1.7). The west side of the West Block centres on 70 Mile Butte (Figure 1.8) which has a good view of the surrounding landscape. Areas in the northwest part of the West Block are more likely to have patches of exposed soil and sparse vegetation (Figure 1.9).

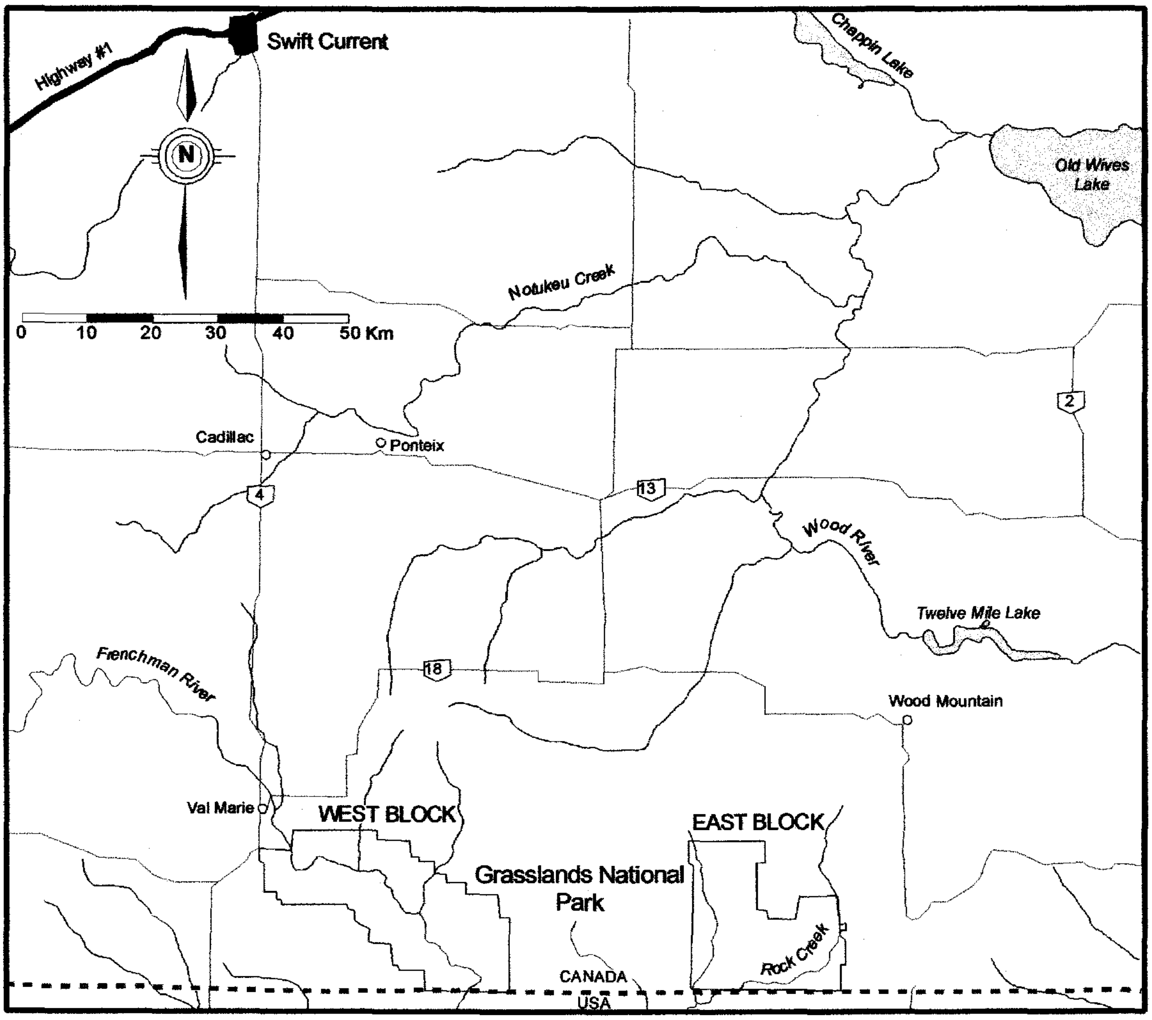

Figure 1.2 Location of Grasslands National Park in Southwestern Saskatchewan.

Figure 1.3 Vegetation Along the Frenchman River in the West Block.

Figure 1.4 Rolling Landscape South of the Frenchman River Valley.

Figure 1.5 Coulee Running North-South, North of the Frenchman River Valley in the West Block.

Figure 1.6 Grassy Plains in the South-central Portion of the East Block.

Figure 1.7 Intermittent Slough in the Area South of the Frenchman River Valley in the WB.

Figure 1.8 View of 70 Mile Butte from the West, from the West Block.

The East Block (Figure 1.2) is made up of rolling to nearly level grasslands which are interspersed with ephemeral drainages. The northern edge of the East Block borders on Wood Mountain and this is the only region within the park where trees grow in any number. Typically, grassy hills are interspersed with wooded drainages (Figure 1.10). The northern edge of the Park rises above the surrounding terrain giving a good view of areas with lower elevation to the south. The southwestern portion of the East Block is largely made up of grassy plains with little change in elevation (Figure 1.6). These are dissected by drainages including Rock Creek (Figure 1.11) which usually contains water year-round. Some seasonal water sources exist in these areas in the form of sloughs, but these tend to dry out as the summer progresses (Figure 1.12). The eastern edge of the East Block is dominated by a valley with Rock Creek flowing through it (Figure 1.13). Just east of the East Block, the landscape abruptly flattens out into close to level prairie. In the southeastern part of the proposed park, including land not yet purchased or surveyed, lie the Kildeer badlands.

Fauna and Flora

A variety of fauna is found within the Park. Ungulates include white tailed deer, mule deer and antelope. Antelope use the Val Marie and Wood Mountain areas as a part of their range and are known to winter in the Frenchman River Valley (Dirschl 1961:13). Elk (wapiti) are known to have inhabited the area and the past and can still be found around Wood Mountain (Lorie Wiesner, Parks Canada, Personal Communication 1998). Sage grouse can be found in the valley and waterfowl can often be found in larger sloughs or on creeks. Eagles, hawks and owls (Figure 1.14) inhabit the Park area along with black tailed prairie dogs and coyotes. Reptiles in the park area include garter and rattle snakes, horned lizards and turtles.

Much of the Park is covered by grasses, particularly in the upland areas. The main species of grass are speargrass, blue grama, western wheatgrass and the non-native crested wheatgrass. The edges of creeks have willows and buckbrush along their edges (Figure 1.15), sometimes together with saskatoons, chokecherries and buffalo berries. Dry slope edges and areas with a

Figure 1.9 Areas of Eroded Vegetation in the Northwest Part of the West Block.

Figure 1.10 A Wooded Drainage at the North End of the East Block.

Figure 1.11 Meander in Rock Creek, South End of the East Block.

Figure 1.12 A Dry Lake in the South-Central Portion of the East Block.

Figure 1.13 The Rock Creek Valley on the East Side of the East Block.

Figure 1.14 Great Horned Owl on the West Side of the West Block.

direct southern exposure often have prickly pear cactus, juniper, sage and rabbit brush. Poplars and cottonwoods are found mainly in the northern part of the East Block where they may grow quite tall (Figure 1.16). Occasional trees are sometimes found near creeks or sloughs.

Climate

In general the climate in G.N.P. is somewhat dry and does not usually experience the extreme winter temperatures common in other parts of the prairies. The annual mean precipitation (1951-1980) for Val Marie, just west of the Park, is 318.4 mm (Atmospheric Environment Service of Canada 1982a:333). Mean daily temperature ranges from –15.4 degrees Celsius in January to 18.9 degrees in July (Atmospheric Environment Service of Canada 1982a:333). The closest weather station recording wind is Swift Current, about 100 km north of the Park. For the period 1955 to 1980, winds blowing from the west or southwest were the most frequent for all months of the year (Atmospheric Environment Service of Canada 1982b:56).

1.2 Geological, Climatic and Ecological History of Southwestern Saskatchewan

A review of changes in geology, ecology and climate over time is essential to a more complete understanding of how people made decisions about site location and settlement. Geological processes cover or destroy sites over time, but in a patterned manner. Understanding these patterns of geological change helps in the reconstruction of missing data. Climate and ecology are linked to the availability of plant and animal resources as well as the availability of water and in this way affect decisions made in the past about site location. With these things in mind, a review of the geological, ecological, and climatic changes during the Holocene in southwestern Saskatchewan should help to better understand changing strategies of the location of precontact human activities within this area.

1.2.1 Geology

According to Klassen (1994:1830), southwestern Saskatchewan was virtually free of ice by 13 500 yr BP. The Wisconsinan glaciation largely shaped the landscape depositing drift over

Figure 1.15 Brush Along the Banks of the Frenchman River.

Figure 1.16 Tall Poplars with Figure for Scale, EB.

much of the area and in this way determining the shape of the landscape. Klassen (1992) divided these landscapes into six types based on development and relative age (Figure 1.17).

During the Wisconsinan glaciation, the western Cypress Hills and the southeastern part of the Wood Mountain upland were nunataks which remained free from ice (Klassen 1992:365, Sauchyn 1990:1505). As a result these areas generally consist of tertiary sediments which have been shaped by stream activity. Similar to this landform area is an area of bedrock with residual drift. The primary difference between this and unglaciated bedrock is the presence of glacial erratics which are considered to be residuals from glacial erosional processes (Klassen 1992:372).

A bedrock terrain with drift complex covers an area within the western part of Wood Mountain. It consists of bedrock covered with a patchy veneer of glacial till and is incised to a large degree with large trunk valleys (Klassen 1992:373). The remaining three landscape complexes are first advance, interlobate, and last advance drift. First advance and interlobate drift areas are mainly comprised of hummocky moraine, while last advance drift, which covers most of the study area, consists mainly of ground moraine and glacial lake plains (Klassen 1992).

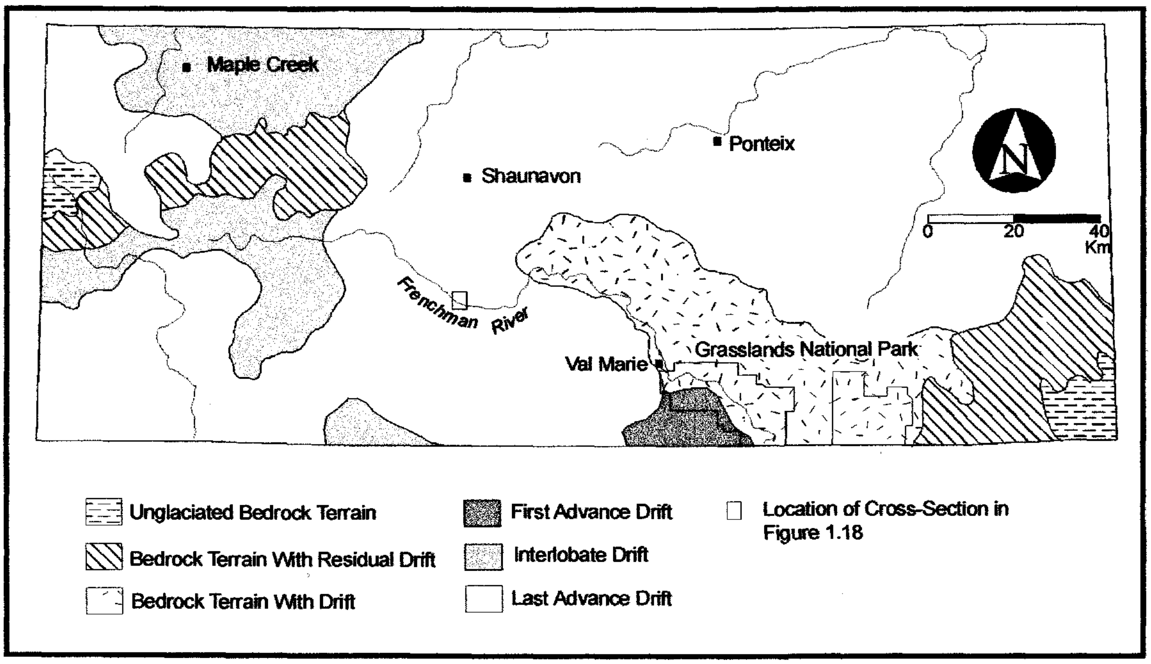

Figure 1.17 Glacial Origins of Landscapes in Southwestern Saskatchewan (after Klassen 1992).

The remainder of this section will focus on geological process after the Wisconsinan glaciation. Of particular concern here are the patterns and rates of postglacial soil deposition and formation. Most non-glacial sediments have been deposited in former meltwater channels occupied by modern streams and within hummocky moraine depressions (Klassen 1994:1827, 1989:146). Eolian deposits such as the Great Sand Hills north of the Cypress Hills may also occur (Klassen 1989:146).

The Ham site, a hummocky moraine depression south of the Cypress Hills, showed three stages of sediment accumulation. The first, deglaciation sedimentation, was dated to ca. 12 630 yr BP and is considered a minimal date (Vreeken 1994:540). This was followed by five cycles of slope erosion, the second being the most intense and indicating possible loss of vegetation cover due to the dry climate of the Altithermal. These cycles were over by 6800 yr BP, as defined by a Mazama ash layer (Vreeken 1994:540). The third stage represents eolian deposits in two cycles. These were not dated, but the last cycle likely represents erosion which occurred during the drought of the 1930s (Vreeken 1994:542).

Sediment accumulation in enclosed lakes also records the various changes in soil erosion and formation. The Harris Lake site in the Cypress Hills (Sauchyn 1990:1507-1509) provides some information on changes in rates of sediment accumulation. From 9120 to 6800 yr BP, sediment accumulated at 0.8 mm/yr indicating a relatively stable landscape. From 6800 to 5120 yr BP the rate of sedimentation was much higher at 1.45 mm/yr. Sauchyn (1990:1508) is attributed to incomplete surface cover and episodic accelerated soil erosion during the Altithermal. From 5120 to 3450 yr BP, sediment deposition was 1.7mm/yr. This is unexpected as it is thought that land cover would have been complete and the landscape fairly stable. Sauchyn (1990:1508) attributes this high rate of deposition to wet conditions which would have caused slope instability and land sliding. From 3450 to 1470 yr BP the rate of sedimentation was 0.99 mm/yr, and from 1470 yr BP to present the rate was 0.28 mm/yr. These figures indicate a return to a more stable landscape.

The records of the Ham site and the Harris Lake site are complex. Both sites point to drying and loss of ground cover during the Altithermal to explain increased rates of erosion. However, the time periods for which the increased erosion was to take place are not quite congruent. As the resolution of the data is not very high, it may be that the same erosional processes are represented at each site and are simply beyond our current ability to define their precise beginning and ending.

The Frenchman River valley is another area of major Holocene sediment deposition. The Frenchman River Valley was formed as a meltwater channel draining proglacial lakes around the Cypress Hills at the time of deglaciation (Klassen 1992:384, Christiansen and Sauer 1988:1703). Klassen (1992:386) states that most of the sediments along the lower parts of the valley were deposited at this time and are incised by modern channels. Based on radiocarbon dates, most of the fill in the valley was deposited between 11000 and 4000 yr BP, with modern channels beginning to incise after this time. Christiansen and Sauer (1988:1704-1706) add further information. The Frenchman River Valley was up to 180 m deep prior to deposition. Landslide activity occurred during the period when the valley carried meltwater and deposited debris during that time. The deposition of alluvial and colluvial sediments started prior to 11500 yr BP and ended about 3500 yr BP. After this time, the rate of sedimentation was greatly diminished and fill in the range of 80 m had been deposited (Christiansen and Sauer 1988:1704-5). Figure 1.18 provides a cross-section of the valley. Klassen (1994:1834) notes that conditions changed from

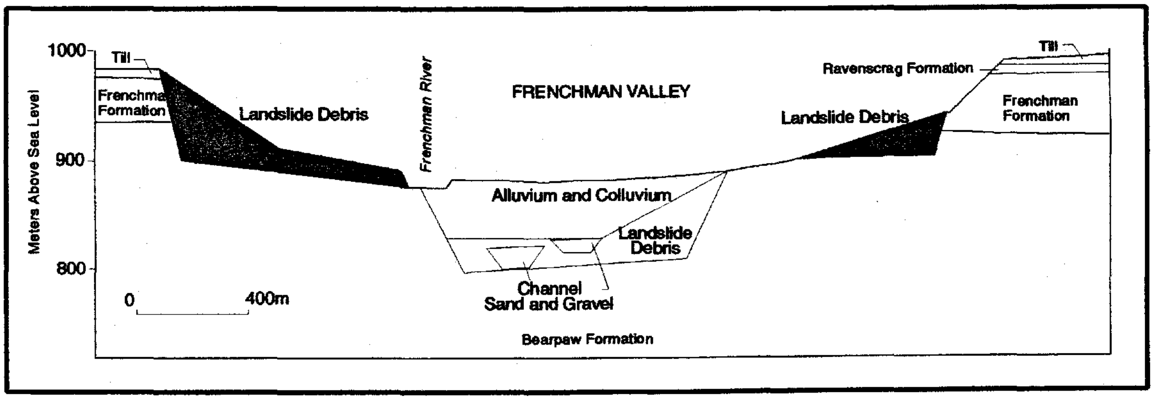

Figure 1.18 Cross-section of The Frenchman River Valley. See Figure 1.17 for Location. (after Christiansen and Sauer 1988).

aggradation to degradation by the modern channel after 6800 yr BP as indicated by Mazama ash in river terrace deposits. He theorizes that degradation probably began after 5000 yr BP when the climate was thought to have become wetter.

Anderson et al. (1989:520) note that studies of floodplains in southern Alberta show that floodplains were stable prior to 6800 yr BP or the Mazama ash fall. A return to a wetter climate here is thought to have led to floodplain aggradation after this time. This pattern is not apparent from Christiansen and Sauer's study of the Frenchman River Valley, as radiocarbon dates indicate continuous deposition until ca. 3500 yr BP (1988:1704).

The Altithermal has been used to explain both increased erosion at the Ham site and Harris Lake site and decreased erosion in southern Alberta. The effect of the Altithermal on deposition in the Frenchman River Valley is hard to gauge, but a decrease in sedimentation is not apparent. Part of the problem lies with defining when the Altithermal occurred and this will be dealt with in the discussion of climate. In general, while the dry conditions of the Altithermal would have reduced precipitation and river flow, the resulting reduced ground cover would appear, at least for southwestern Saskatchewan, to have resulted in increased or continuing sedimentation in depressions and river valleys.

1.2.2 Climate

Information derived from sediment cores taken from hummocky moraine depressions and saline lakes has provided some data on which we may try to reconstruct the climatic change in southwestern Saskatchewan. This evidence is often difficult to interpret as time scales are coarse and the processes of climate change are not well understood. Figure 1.19 provides a chronology of some of the sites dealt with here. Wendland (1978) provided a basic chronology of climate change for the Holocene in North America. The cool pre-Boreal period (10030 BP to 9300 BP) was followed by warming in the Boreal period (9300 BP to 8490 BP) and a greatly increased warming or drying during the Atlantic or Altithermal (8490 BP to 5060 BP). This was particularly true for 7000 to 5500 BP. Following this, the sub-Boreal period (5060 BP to 2760) was a

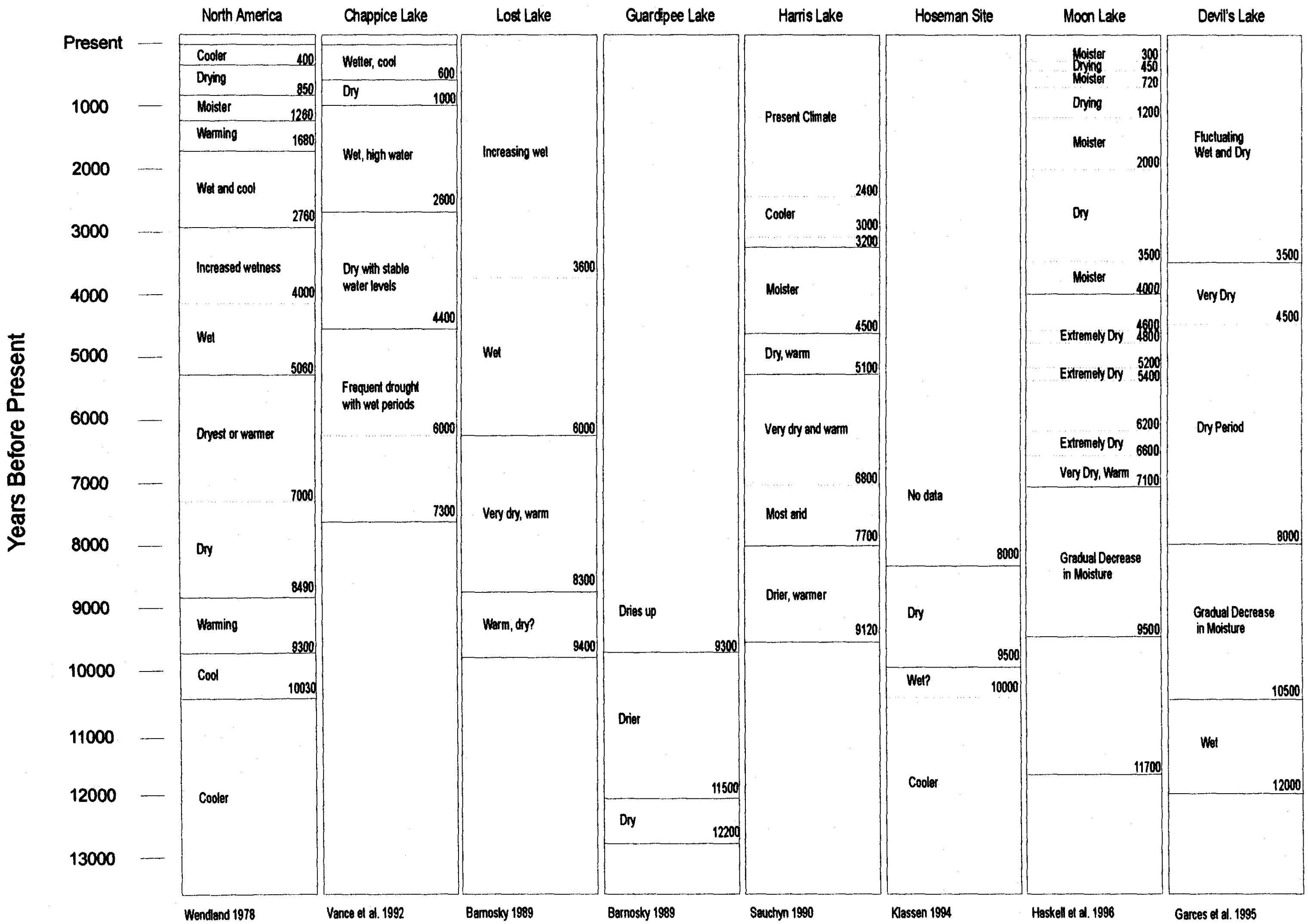

Figure 1.19 Climate Chronologies for Sites on the Northwestern Plains.

time of increasing wetness, particularly after 4000 BP. This was followed by the sub-Atlantic (2760 BP to 1680 BP) which was cooler, then the warmer Scandic (1680 BP to 1260 BP), and the neo-Atlantic period (1260 BP to 850 BP) which was warmer and then wetter. Finally, increased drying occurred with the Pacific (850 BP to 400 BP) followed by a cooler climate during the neo-Boreal or "Little Ice Age" (400 BP to 100 BP). The last approximately 100 years have been similar to the present climate. How does this compare to records of climatic change in southwestern Saskatchewan and neighbouring areas? Harris Lake provides the most complete records of climatic change for the area of southwestern Saskatchewan, and pollen records from the Horseman site help to fill out the earlier part of the Holocene.

The Horseman site is a depression situated on the Old Man On His Back Plateau just south of the Cypress Hills upland. Radiocarbon dating of peat from the bottom of this depression and analysis of pollen has provided some climatic information about the early Holocene. After deglaciation ca. 13000 yr BP, the climate at the Horseman site was cooler than today and semi-arid (Klassen 1994:1833). This appears to have been the climate until about 9500 yr BP. From 9500 to ca. 8000 yr BP conditions became more arid (Vreeken 1994:541).

The Harris Lake site (Sauchyn 1990:1506-1508) picks up where the record at the Horseman site ends. Climate conditions are inferred from the pollen record and relative amounts of organic matter in sediments. Although the Horseman site and Harris Lake site occupy two different climatic zones, climate changes described are relative and are assumed to have been occurring over all of southwestern Saskatchewan. Conditions drier and warmer than present are indicated from 9120 to 7700 yr BP. From 7700 to 5100 yr BP, conditions were much drier and warmer than present with the period from 7700 to 6800 yr BP being particularly dry. Sauchyn (1990:1507) interprets as being the Altithermal period. The period from 5100 to 4500 yr BP was still warmer and drier relative to present climate conditions, but less than the Altithermal. From 4500 to 3200 yr BP, conditions appear to have been moister than at present. After 3200 yr BP, conditions appear to have been similar to those of the present although until 2400 yr BP conditions seem to have been cooler.

A comparison of this chronology with reconstructions of climate for other sites in the region is instructive. Chappice Lake near Medicine Hat in southeastern Alberta (Vance et al. 1992:880-881) provides another record of mid to late Holocene climate change. Pollen, sediment, and lake level analysis provide the basis for the reconstruction. While Harris Lake shows indications of great aridity during the Altithermal, Chappice Lake suggests a different pattern. These data indicate the Altithermal probably begins prior to 7300 yr BP, and ends by 4400 yr BP. Instead of a period of great aridity at the beginning of this period, Chappice lake shows a period of huge fluctuations in lake level from dry to higher levels. After ca. 6000 yr BP, conditions are dry but stable (Vance et al. 1992:881). Unlike Harris Lake, Chappice Lake shows variation in late Holocene climate with a period of drought from 1000 to 600 yr BP and increased moisture after 600 yr BP until about one hundred years ago.

In northwestern Montana, Guardipee and Lost Lakes provide another Holocene record of climate (Barnosky 1989). Dry conditions appear to have been prevalent from 11500 to ca. 9500 yr BP at Guardipee Lake, after which the lake appears to have been mostly dry until more recently (Barnosky 1989:65). At Lost Lake, pollen and sediment analysis indicate possibly warmer and drier conditions from 9400 to 8300 yr BP and good indications of dry climate from 8300 to 6000 yr BP. From 6000 to 3600 yr BP, climates were moister and from 3600 yr BP on, slightly wetter climates prevailed (Barnosky 1989:67-68).

Devil's Lake in northeastern North Dakota provides a record of climate to the east of Saskatchewan. Using an analysis of the water chemistry and sediment Haskell et al. (1996) were able to reconstruct some aspects of past climate. Climates were generally wetter from 12 000 to 10 500 yr BP but become increasingly dry from 10 500 to 8000 yr BP when the climate appears to have become very dry (Haskell et al. 1996:189). From 8000 yr BP on the climate was dry but becomes wetter from 3500 to 4500 yr BP. From 3500 yr BP on climate was drying but with fluctuations in the record (Haskell et al. 1996:190).

Data from Moon Lake in southeastern North Dakota also provide a record of Holocene climate for the area. Initially (11 700 – 9500 yr BP), the climate was cool or wetter but there was a gradual drying of the climate from 9500 to 7100 yr BP (Valero-Garcés et al. 1996:367). From 7100 to 4000 the climate was arid, marked by a number of periods of extreme aridity. From 4000 yr BP the climate became moister but fluctuated between periods of drying and increasing moisture (Valero-Garcés et al. 1996:367).

A number of points arise when these different climatic records are compared. One is that the onset of the Altithermal appears to vary from region to region. In northwestern Montana, the very dry climate patterns appear to be over by 6000 yr BP. In contrast, the Harris Lake record shows the Altithermal over by ca. 5100 yr BP, and it is over by 4400 yr BP at Chappice Lake. The Altithermal appears to be over by 4000 yr BP at Moon Lake. While Harris Lake and Lost Lake simply show a "dry" climate during the Altithermal, Chappice and Moon lakes show indications of extreme fluctuations in climate, causing the level of the lake to range from dried up to high water levels at Chappice Lake. Similarly, from ca. 3400 yr BP on, Harris and Lost Lakes show little sign of changes to the climate, while Chappice Lake shows fluctuations in climate similar to Wendland's (1978) construction of Holocene climate and Moon Lake shows a series of climate fluctuations (see Figure 1.19).

Of primary concern here is whether the more homogeneous nature of the Harris and Lost Lake records is due to actual climatic history or whether a finer resolution of climatic information was available from Chappice and Moon Lakes. Chappice Lake appears to have a more distinct record of water level change throughout the Holocene and much of the climatic reconstruction is based on this record of change (Vance et al. 1992:881). Moon Lake makes use of several climate indicators including sediment, water chemistry, diatoms and pollen to reconstruct climate (Valero-Garcés et al. 1996:359). Harris and Lost Lakes appear to be less distinct in their record of water levels and a less diverse range of climate indicators was used than for Moon Lake (Barnosky 1989, Sauchyn 1990) and this may account for a certain loss of detail in terms of climatic change. This may be due to the fact that

> ...the last few millennia may be too short for even the faster responding climatic indicators to reach full equilibrium with the climate though it is clear that locally significant changes did occur (Bryson and Wendland 1967:281).

Thus the climate fluctuations indicated in the Chappice and Moon Lake records in the late Holocene may still have occurred in southwestern Saskatchewan despite lack of direct evidence.

1.2.3 Ecology

The ecology of southwestern Saskatchewan is linked to changes in climate. Vegetation responds to changes in climate, but to a lesser degree than animals as the spread of vegetation is slower (Klassen 1989:163). In a general appraisal of the vegetational history of the western interior of Canada, Ritchie (1976) proposed that spruce forests dominated the landscape from 14000 to 10500 yr BP, followed by grassland vegetation. This change has been placed at 10000 yr BP at Herbert and 10600 yr BP at Hafichuk in southern Saskatchewan and has been attributed to warmer and drier conditions with an increase in frequency of fires (Anderson et al. 1989:525). In the area of southwestern Saskatchewan, grasslands dominated until the present (Ritchie 1976).

Some more recent local studies of vegetation within southwestern Saskatchewan have helped to refine our understanding of the vegetation history in this region. The previously mentioned Horseman site, as yet unpublished as a separate study, provides evidence from pollen analysis that from 14300 to 9500 yr BP open sage and grass vegetation existed with spruce, pine, poplar and willow (Vreeken 1994:541). Klassen (1994:1833) suggests that tree growth may have consisted of "aspen parkland, mixed-deciduous forest transition and (or) subboreal broad-leaved forest." This differs from the picture of early Holocene vegetation painted by Ritchie (1976). At the Val Marie site east and south of the Frenchman Valley, a pollen record of pond sediments with a basal date of about 10000 yr BP shows three main pollen assemblages (Klassen 1994:1834). The presence of grasses and sage indicates dry prairie throughout the record with increased wetness or cooling in the middle of the record leading to a increase in pine trees in the area.

The Harris Lake site, recording vegetation in the Cypress Hills, is divided by Sauchyn and Sauchyn (1990:1507-1508) into five periods. The first, 9120 to 7700 yr BP is characterized by a poplar-grassland-shrub complex that was becoming more prairie-like. The second zone, 7700 to 5000 yr BP is characterized by lower numbers of trees and aquatic plants and an increase in herbs and plants which grow in disturbed (presumably eroded) soil. The period 5000 to 4500 yr BP shows an increase in trees and the period 4500 to 3200 yr BP shows a "substantial and rapid" increase in forest cover and aquatic pollen (Sauchyn and Sauchyn 1991:19). The final zone, 3200 yr BP to present, shows little change in vegetation.

In northwestern Montana, analysis of pollen from Guardipee Lake suggests that from ca. 12200 to 9500 yr BP an environment of dry grassland and herbs existed (Barnosky 1989:64). Klassen suggests that this is similar to the environment at the Horseman site for the same time period (1994:1833). At the Lost Lake site, steppe shrubs may have been prevalent from 8300 to 6000 yr BP. From 6000 to 3600 yr BP, vegetation was grassland with increased alder, birch and willow along the lake shore. After 3200 yr BP, wetter conditions led to greater numbers of trees being present in the area (Barnosky 1989:68).

The reconstruction of fauna in southwestern Saskatchewan is difficult as sites with records of fauna for the Holocene are rare (Graham et al. 1987:427, Harrington 1978:26). Faunal assemblages from Cactus Flower site, southeastern Alberta and Oxbow Dam site, southeastern Saskatchewan, which are greater than 4000 years old, resemble modern faunal assemblages (Graham et al. 1987:428). According to Klassen (1989:164), between ca. 15000 to ca. 9000 years ago massive extinctions left "rodents, rabbits, hares, beaver, smaller carnivores, pronghorn, mountain sheep, bison, and some of deer, caribou, and elk" intact, with many formerly prominent taxa becoming extinct, including "elephants, horses, camels, ground sloths, ...lions, sabre-toothed cat, and dire wolf". In general, Graham et al. (1987) see the development of Holocene fauna on the Northern Plains as being connected to variations in environments which were determined by climate. The available faunal evidence does not permit a reconstruction of the relative abundance of one taxa over the other as the sites that are known are sparse.

Ecologically and climatologically the Holocene was a time of varying resources and resource predictability. The mass extinctions at the beginning of the Holocene would have had an enormous effect on people who had been hunting megafauna. The mass extinctions leave bison as a dominant herbivore on the plains and an adaptation to bison hunting shortly after is apparent (Dyck 1983:73).

Given the ecological and climatic periods and changes, the degree to which bison hunting was important and the methods used to hunt them would have to have changed to adapt to different environmental conditions. Morgan (1980:143) noted that the "availability of superior forage" was primary in determining major bison movement patterns. The availability of this forage may have changed considerably through time. At the beginning of the Holocene climate appears to have been relatively stable, with cooler temperatures but probably suitable forage for bison as grasses were abundant in southwestern Saskatchewan.

During the Altithermal, there is evidence for greatly decreased land cover and forage for bison would have been poorer on the plains of southwestern Saskatchewan with possibly better forage in the Cypress Hills and Frenchman Valley. Adams (1986:6) identifies the Frenchman Valley as a winter habitat for ungulates. During the dry periods of the Altithermal, it may have been that the Frenchman River Valley had too sparse cover to have provided an adequate habitat during the winter and bison may have ranged further away out of area at this time. If one considers the climatic evidence from Chappice Lake, the Altithermal may have been a period of very dry climate with alternate cooler wet periods. This would have made forage a very unpredictable resource likely making bison movements unpredictable as well. Thus, the diversification of the resource base may have been a required strategy among peoples at that time so that if bison failed to appear when and where they were anticipated other resources were still available for subsistence. The areas of greatest resource diversity in southwestern Saskatchewan are the Cypress Hills, and the Frenchman River Valley and Wood Mountain. It may be found that sites from the Altithermal time period primarily occur in these areas.

The period after the Altithermal was moister with more stable vegetation. Forage for bison would have been more abundant and predictably located season after season. For all climatic records, climate seems to have stabilized by ca 3500 yr BP. It may be after this period that the "classic" patterns of bison migration as described by Morgan (1980:150-155) may have developed. This may have paved the way for the development of communal bison hunting techniques such as pounds and jumps which require the prediction of bison movements to a certain degree and it may be after this period that we find these sites first occurring in suitable areas. The Kobold site in southern Montana provides evidence that bison jumps began to be used after the Altithermal (Frison 1970:1). Climatic fluctuations indicated at Chappice Lake and Moon Lake at the end of the Holocene may have required some adjustments and adaptation in terms of bison movements and site location, but these fluctuations were much shorter and less intense than the Altithermal and thus probably much less disruptive. If the present climate can be taken as generally similar to climates up to 5000 years ago, water sources would still have been important sites, and we might anticipate concentrations of sites there.

1.3 Culture History of the Northern Plains

This section will provide a sketch of the different cultural groups identified by archaeology as having occupied the Northern Plains. While the research itself will not be able to separate different cultural patterns of landscape use (see Chapter 3), this section will help to provide a picture of past life ways which would have had a general bearing on patterns of landscape use.

The archaeological past of the Northern Plains has been divided into various periods based on ecological and cultural changes. A recent cultural chronology by Walker (1992:120-121) provides a good framework for the history provided here.

1.3.1 The Paleo-Indian Period

Although the presence of people in the Americas has been established as occurring prior to 12 000 B.P. (Adovasio and Pedler 1997:578), there has not been any archaeological evidence of their presence in Saskatchewan. In terms of settlement patterns, Wright (1995:40) sees the earliest cultures which inhabited North America as having somewhat different settlement patterns than those of later periods, as the first cultures would effectively be colonizing previously uninhabited continent. On the Plains, Paleo-Indian settlement seems to be primarily related to good sources of lithic material (Wright 1995:44).

Clovis

The Clovis complex is the earliest known complex to have occupied Saskatchewan. They are not well represented in the archaeological record of southern Saskatchewan with sites consisting only of surface finds. As a consequence there are no dated Clovis components from Saskatchewan but in general Clovis occupations date between 11200 and 10900 radio-carbon years before present (rcybp) (Haynes 1993:220). The Clovis complex is characterized by large fluted projectile points which have been recovered across the North American continent (Haynes 1982:383).

Frison (1991:39) sees the Clovis complex on the Plains as a big game hunting adaptation where mammoth and bison were hunted. He interprets the mammoth kill at the Colby site in Wyoming as an arroyo trap where a wounded mammoth might be killed while other kills might have been more opportunistic (Frison 1991:149-150). Hunting technology included projectile points made of bone and ivory as well as stone which were hafted onto foreshafts for a projectile weapon (Frison 1991:41).

Stanford (1991:5) notes that the Clovis culture may not have been as focused on big game hunting as originally thought. Recent evidence suggests that Clovis peoples were generalists, making use of a variety of plant and animal resources. It may have been the case that Clovis peoples, while retaining some degree of consistency in archaeological assemblages, were regionally adapted to the places in which they lived and used a subsistence strategy based more on foraging than on big game hunting where appropriate (Meltzer 1993:295). Clovis campsites show a tendency to be associated with water sources often found near springs, river terraces, or the shorelines of extinct lakes (Stanford 1991:5, Meltzer 1993:303). Excavated campsites are generally small and temporary with a few larger sites associated with quarries (Stanford 1991:5). Clovis assemblages often have exotic lithic sources suggesting that Clovis peoples ranged widely in their travels or trading relations (Frison 1991:41).

Goshen

Currently, the Goshen complex is known from Wyoming and southeastern Montana, and dates on either side of 11000 rcybp (Frison 1991:45). Projectile points are large and unfluted and appear to have characteristics of both Clovis and the later Folsom point types (Frison 1991:44). While it has been suggested that Goshen was a variant of Clovis, the most recent evidence suggests that Goshen is a transition between Clovis and Folsom (Bonnichsen 1991:314).

Folsom and Midland

This complex is characterized by large projectile points with an extremely large flute on either side (Folsom points). An unfluted variant is also known (Midland points). No Folsom sites have been excavated in Saskatchewan although surface finds exist. This complex dates between 10900 rcybp and 9900 rcybp (Dyck 1983:75). During this period mammoth appear to have died out with hunting focused on bison and smaller game. At the Agate Basin site in Wyoming, bison, pronghorn, canids, and rabbits were found in the Folsom component of the site (Frison and Stanford 1982:39).

Folsom point technology has been of great interest to archaeologists because of the great skill required to create the large flutes on the Folsom point. It has been suggested that this flute served a more artistic purpose than a functional one (Frison 1991:51). Other aspects of Folsom material culture suggest that the Folsom people were as sophisticated in their manufacture of clothing and ornamentation as they were at manufacturing projectile points. Bone needles and incised ornamental bone pieces are evidence of high quality clothing (Frison 1991:51).

Agate Basin/Hell Gap

Agate Basin and Hell Gap are closely related in time and appear to be related complexes. Frison (1991:62) sees Hell Gap developing directly out of Agate Basin. Agate Basin points are "smoothly lanceolate with basal edges," while Hell Gap points have "slightly constricted edges between the base and the mid-point" but are generally similar (Dyck 1983:76). The points were mounted on the socketed foreshafts of thrusting spears (Wright 1995:101).

Agate Basin points date from 10 500 to 9400 rcybp while Hell Gap points date 10 240 to 9600 rcybp (Dyck 1983:76). The Parkhill site, a large surface site, represents the only major Agate Basin site in Saskatchewan (Dyck 1983:76). In terms of distribution, Agate Basin points are wide-spread while Hell Gap points are more limited to the Plains region (Wright 1995:104).

On the Plains, bison are the primary animal hunted by these groups although Wright (1995:108) warns that mass bison kill sites may be overemphasized in the record due to their greater visibility. One communal hunting site known from these cultures is the Agate Basin site in Wyoming . Here bison were trapped in a steep walled arroyo, most likely in the winter (Frison and Stanford 1982). In addition to bison some antelope remains were found in a Hell Gap level.

Alberta/Cody

The Alberta and Cody complexes are related through time and space. The Alberta complex is earliest ranging 9500 to 9000 rcybp (Frison 1991:62). Large long points with distinctive shoulders are characteristic of the Alberta Complex. Frison (1991:61) suggests that a form of projectile point transitional between Alberta and Cody types exists at the Horner Site in Wyoming. This form, called "Alberta-Cody" dates older than most Cody components. The Cody complex dates generally 9000 to 8400 rcybp (Frison 1991:66). Scottsbluff and Eden points, along with an angular biface called a "Cody knife", are characteristic of this complex. Within Saskatchewan a Cody component at the Heron Eden site has been dated to older than 8000 rcybp (Morlan 1993:37). This site consists of two mass bison kills which were conducted during the winter (Corbeil 1995:83). It is not clear what topographic features were made use of to trap the bison, or whether man made structures were made use of (Corbeil 1995:127).

The Horner site provides us additional information on subsistence strategies. No topographic features at the site appear to have been useful for trapping the bison that were killed there. Despite the lack of corroborating physical evidence, Frison and Todd (1987) suggest that some sort of corral structure may have been used as a trap. Frison and Todd (1987:367) also note that at the Horner site and other Paleo-Indian sites, heavy processing of bone is not present unlike later periods. This suggests that bone grease was not as important during the Paleo-Indian period as it was in later periods when it may have been used for making pemmican and other uses.

Late Paleo-Indian Groups

Towards the end of the Paleoindian period, a number of different groups appear. Lanceolate projectile points known as Frederick, Lusk, Angostura and Browns Valley are known from surface finds in Saskatchewan. They date approximately 9200 to 8000 rcybp (Dyck 1983:82). Jimmy Allen points, not yet known from Saskatchewan but known from the Northern Plains, date later at 8500 to 7900 rcybp (Dyck 1983:83). These points are similar in form to Frederick points. Characteristic of points from this time are parallel-oblique flaking patterns (Frison 1991:66). While not much is yet known about these cultures, it is interesting to note that a mano and metate were found in a Lusk component at the Betty Greene Site in Wyoming, suggesting possible plant processing (Frison 1991:67). Groups in foothills-mountain areas at this time are distinct from Plains groups in terms of subsistence, following a more generalized hunting and gathering economy (Frison 1991:68).

1.3.2 The Middle Prehistoric Period

Mummy Cave

The beginning of the Early Middle Prehistoric period experienced an ecological change due to an increasingly dry and warm climate (see section 1.3.3 above). This change had the effect of reducing the number of bison and people on the Plains. While at one time it had been suggested that people had completely abandoned the Plains at this time, recent archaeological evidence has shown this to be untrue (Walker 1992:143).

The Mummy Cave complex consists of a number of different side-notch atlatl point styles, including Bitterroot, Salmon River (Reeves 1973:1244-1246) or Gowen (Walker 1992:132-142), and Hawken (Frison et. al. 1976:41-46). These side notched points are thought to signify a transition from thrusting spear weapons to the atlatl or spear-thrower (Wright 1995:127). The Mummy cave complex generally dates 7700 – 4700 rcybp (Dyck 1983:92) with dates ranging from 6100 – 5500 rcybp for Saskatchewan (Morlan 1993:37).

While it appears that subsistence systems took on more of a foraging pattern for some areas, bison hunting was still quite prevalent on the Northern Plains (Walker 1992:144). The Hawken site from northeastern Wyoming is an example of an Early Middle Prehistoric communal bison kill. Here, almost 100 bison were trapped in an arroyo using communal methods during one or more winters (Frison et. al. 1976:53-55).

Mummy Cave sites appear to have been located in such a way as to compensate for the dry climatic conditions. Walker describes Early Middle Prehistoric sites:

> The majority of the known Early Middle Period sites were short duration, open campsites of limited areal extent and sparse cultural assemblages. These sites were usually located adjacent to reliable sources of water (1992:144).

In addition to being close to reliable water, it has been suggested that people during this period made use of "refugia" (Frison et. al. 1976, Buchner 1980) consisting of areas like the Black Hills of South Dakota which had localized climates which were less dry than the surrounding areas. These areas in turn were richer in game and plant resources.

Oxbow

The Oxbow complex follows the Mummy Cave complex and is likely derived from it (Millar 1981a:156). The Oxbow complex is identified by projectile points with "eared" bases which are very distinctive. Within Saskatchewan, Oxbow dates 5500 - 3860 rcybp (Morlan 1993:38). By Oxbow times, the Plains are no longer as dry or warm as they once were and as a result archaeological remains from the period become more frequent. Although the Oxbow peoples were definitely bison hunters, an Oxbow communal bison kill site has yet to be discovered in Saskatchewan (Dyck 1983:96). It is not clear whether this is due to sampling or whether the

Oxbow peoples used hunting methods of which we are not yet aware. Recent work at the Oxbow Dam site, for which this complex is named, has shown that Oxbow peoples used a variety of species as food sources including canids and turtles (D'Arcy Green 1998, personal communication). While little has been said specifically about Oxbow settlement patterns, Amundson (1986:197) has noted that Oxbow sites tend to be near reliable water sources like streams, rivers or channels. It is with Oxbow that the first sites with stone rings (often known as tipi rings) are known (Wright 1995:316). Unique to Oxbow in Saskatchewan is a precontact cemetery known as the Gray Site. From this site near Swift Current 304 individuals from 99 burial units were uncovered (Millar 1981b:104). Rolled copper from the Gray Site and a copper crescent from the Castor Creek Site in Alberta (Dyck 1977:7) show that Oxbow had trade links to areas as far away as the Great Lakes region.

McKean

The McKean complex in Saskatchewan dates 4450 - 3000 rcybp (Morlan 1993:38), making it later but to some degree contemporaneous with Oxbow. The complex is identified by three different atlatl points: McKean Lanceolate, Duncan, and Hanna. In an analysis of Saskatchewan radiocarbon dates Morlan (1993:39) observes that McKean Lanceolate points are older than either Duncan or Hanna points while Duncan and Hanna points are more or less contemporaneous.

McKean peoples are not seen as having developed out of previous local cultures, but are thought to have originated in the Great Basin (Brumley 1975:101). While this is the majority opinion, some view McKean as developing out of Oxbow (Wright 1995). The subsistence strategy used by McKean peoples appears to change depending on geographic location. It has been noted that McKean sites in Wyoming and Montana have grinding stones, possibly for vegetable food preparation, while sites north of the 49th parallel do not (Frison 1991:89, Brumley 1975:98). Another feature that is lacking further to the north is the pit house (Frison 1991:97). One interpretation for this pattern has been that southern McKean peoples had a more generalized subsistence using a variety of plants and animal species, but switched to a more exclusive focus on bison upon moving northward (Brumley 1975:102). Ramsay (1993:46) suggests a degree of bias may have been introduced into the record because southern sites are drier and have better preservation while northern sites are less likely to have had flotation or fine screening of remains.

Communal bison hunting is known to have been conducted by the McKean peoples. The Kobold site in Montana provides evidence of a large scale McKean bison jump (Frison 1970). In terms of settlement locations, Wright (1995:316) observes that McKean sites tend to be near marshes, sloughs, major rivers and tributaries, and along major moraines.

Pelican Lake

The Pelican Lake complex is identified by corner notched atlatl points; although it has been suggested that some Pelican Lake points are arrow points (Dyck and Morlan 1995:503). Pelican Lake dates between 3780 and 2120 rcybp in Saskatchewan (Morlan 1993:39).

Reeves (1983) sees a regional distribution of subsistence patterns for Pelican Lake that is similar to McKean distributions. Sites south of the Missouri have a large number of grinding slabs and handstones. Reeves sees southern Pelican Lake groups as having a more generalized mode of subsistence, not necessarily with a primary reliance on bison. The lack of grinding implements north of the Missouri indicate to Reeves a dependence on communal bison hunting (Reeves 1983:87). Foor (1982:111) states that it is during this period that we see the first use of pounds for bison hunting although Frison (1991:171) suggests that a corral structure may have been used to trap bison at the Hell Gap associated Jones-Miller site in eastern Colorado.

Pelican Lake peoples appear to have had some far reaching trade connections. Articles made from Pacific coast shells as well as an article of native copper were recovered from the Highwood River burial in Alberta (Brink and Baldwin 1988:124). An article of rolled copper was also found in the Bracken Cairn in southwestern Saskatchewan (Walker 1982:31) indicating possible trade links with the Great Lakes region. Within Saskatchewan, Knife River Flint from North Dakota is a common lithic material found in Pelican Lake components (Reeves 1983:86).

1.3.3 The Late Prehistoric Period

Besant

The Besant Complex is identified by side notched atlatl points as well as arrow points called Samantha points (Reeves 1983:140). Besant points show a certain degree of variability which has lead some researchers to divide Besant into more points styles (see Dyck and Morlan 1995). Within Saskatchewan , Besant dates from 2900 to 1400 rcybp (Morlan 1993:39).

The Besant people are known as one of the most sophisticated bison hunting groups to have existed on the Northern Plains (Frison 1991:105, Dyck 1983:113). They were expert users of the bison pound, a method of hunting where bison were driven into a corral through a set of drive lanes where they could be shot with atlatl darts and arrows. At the Ruby site in Wyoming, it was discovered that in addition to a corral structure for trapping the bison, a ceremonial structure with a set of bison skulls accompanied the pound (Frison 1971:85-86). This provides a link between the observed spiritual significance of bison pounds during historic times (Verbicky-Todd 1984:115) and the activities of Plains groups living 2000 years ago.

Knife River Flint from North Dakota is unusually common at a some Besant sites while obsidian from the Rockies is rare (Reeves 1983:96). This suggests strong trading relationships over a long distance (Dyck 1983:115). With the Besant peoples we also see the arrival of pottery on the plains (Reeves 1983:96). Besant peoples, while making use of tipis, also used post-in-ground houses which may have had similarities to Eastern Woodland bark covered houses (Dyck 1983:113).

Avonlea

Avonlea is identified by finely crafted side notched arrow points. The dates for Avonlea in Saskatchewan range from 1960 to 930 rcybp which means that this culture overlapped with Besant to some degree (Morlan 1993:40).

The Avonlea peoples were again bison hunters, making use of pounds, jumps, and traps (Reeves 1983:105). Unlike previous periods, the primary projectile weapon was the bow (Davis and Fisher 1988:103; Vickers 1994:14) which marks a significant departure from the thousands of years of use of the atlatl. Davis and Fisher (1988:103) suggest that our understanding of Avonlea subsistence is biased toward communal bison hunting because these sites have greater visibility. There is some evidence of a greater subsistence diversity. Smith and Walker (1988:86) have noted that the Lebret Site in Saskatchewan is an Avonlea spring fishing camp which could have provided a food source when other resources were scarce. In addition, fragments of manos and grinding slabs are known from Avonlea sites in Wyoming and Montana suggesting significant plant use (Frison 1988159-164).

Unlike Besant groups, Avonlea sites are characterized by local lithic sources. This may have meant that Avonlea peoples did not have as far reaching ties as groups before or after them (Milne 1988:64). Avonlea people made some use of ceramics (Reeves 1983:104). In terms of a settlement pattern, Milne (1988:65) describes Avonlea site locations in southeastern Alberta: "related but distinct camp and kill locales, often located near a stream, suggest a patterned settlement system." In addition, Milne (1988:65) sees camp, butchering and kill "activity areas" within Avonlea sites.

Late Side-Notch Series

Prairie Side-Notched and Plains Side-Notched points are characteristic of this series. They are thought to have evolved out of Avonlea and may have been contemporaneous at some sites (Adams 1977:141, Morlan 1993:40). It has been suggested that the Sheep Camp site near Cabri, Saskatchewan has an assemblage which is transitional between Avonlea and the Late Side-Notched series (Amundson 1986:200). Prairie and Plains Side Notched points date from 1400 to 0 rcybp (cal 1300 to 170 BP) within Saskatchewan (Morlan 1993:40). While sometimes found mixed together, Prairie Side-Notched types generally precede the Plains Side-Notched types (Morlan 1993:40).

Associated with Plains and Prairie Site Notched points are different ceramic wares. Old Women's phase ceramics are found in Alberta and Saskatchewan (Vickers 1994:23) and are found at sites into the protohistoric period (Vickers 1986:106). While lacking a definitive connection, the Old Women's phase is often thought to be ancestral to modern Blackfoot groups or possibly the Gros Ventre (Vickers 1986:101-102). During this time we also see Mortlach phase ceramics in Saskatchewan which have characteristics of the Middle Missouri Plains Village tradition (Vickers 1994:24) although Walde (1994:135) argues that Mortlach and Middle Missouri pottery are not equivalent. Malainey (1991:369) describes the distribution of Mortlach pottery as covering south-central Saskatchewan, northeastern North Dakota and northwestern Montana. Similarly Walde (1994:102) locates the Old Woman's phase in southwestern Saskatchewan while the Mortlach phase is located in south-central and southeastern Saskatchewan. Based on these descriptions G.N.P. would lie along the edge of the distributions of Old Women's and Mortlach phases.

1.3.4 Historic Groups in Southwestern Saskatchewan at the Time of Contact

The locations of Historic Native groups on the Canadian plains at the time of contact are difficult to establish due to the migrations of various groups in response to pressures from European presence (Brink 1986:1) and epidemics (Ray 1974:104). The issue is further complicated by the likelihood that Native groups did not occupy static areas but likely shifted locations through time (Brink 1986:60). Adding to this is the fact that the Park area lacks written records of early trade or journeys through the area (Loveridge and Potyondi 1977:68).

The southwestern part of Saskatchewan may have been inhabited by either the Hidatsa or the Atsina (Gros Ventres) at the time of contact. Magne (1987:225-224) puts southwestern Saskatchewan under the influence of groups associated with the Hidatsa. Their expansion west from the Middle Missouri area is indicated by the Cluny Earthlodge Village located on the Bow River, south central Alberta (Magne 1987:225). Based on the accounts of early European traders and travellers to Saskatchewan Russell (1991:212) demonstrates that Hidatsa groups likely resided in the southeastern parts of the province, while the Atsina were located in the southwestern part of the province at the time of contact. Loveridge and Potyondi (1977:68) note that the

Gros Ventre or Atsina made particular use of the Wood Mountain area prior to the middle of the eighteen century. If there is continuity between Old Women's ceramics and the Gros Ventre or Atsina as noted above, the archaeological evidence would tend to support the findings from historic records that Atsina groups occupied southwestern Saskatchewan at the time of contact. .

The Assiniboin were well established in the Saskatchewan Valley area at the time of contact (Russell 1991:186) but came to exert influence over the Park area during the second half of the 1700's (Loveridge and Potyondi 1977:68). Magne (1987:225) also locates the Assiniboin in the east-central portion of the province at the time of contact. This corresponds roughly with a map of contact period groups in Alberta put forward by Brink (1986:57). Walde (1994:135-136) argues that Mortlach pottery from south-central Saskatchewan is most closely related to historic Assiniboin groups, not groups from the Middle Missouri area. This would place Assiniboin groups in southern Saskatchewan during a period which extended into early precontact times.

Further complicating our understanding of the locations of historic groups at contact is the fact that various groups are known to have their origins in places other than the Plains. For example, the Assiniboin and Siouan groups in general have their origins in the woodlands of Minnesota (McMillan 1995:154) and the Atsina originate in southern Wyoming and northern Colorado, migrating to the Canadian plains prior to the arrival of Europeans (McMillan 1995:151). In general the southwestern part of Saskatchewan has not been observed historically to have been occupied exclusively by one specific group and may have been a region used by a number of groups at one time. Loveridge and Potyondi (1977:68-70) characterize the Park area as a "neutral zone" between various cultural groups during the postcontact period. However, the large number of archaeological sites within G.N.P. suggests that in precontact times the Park was not a border area but was used intensively by people.

2.0 A Review of Settlement Studies on the Northern Plains and Theoretical Considerations for Using Geographic Information Systems

2.1 GIS And Regional Environmental Analysis

2.1.1 The Definition of Regional Environmental Analysis

Regional Environmental Analysis has been defined by Kvamme (1989:168) as an analysis which seeks to find correlations between environmental variables and archaeological site distributions or land use. Practically, this often means that research revolves around the comparison of site locations with maps of different environmental themes in search of associated patterns of site distribution. These patterns can be detected statistically or visually, but both methods are usually important to an analysis. Regional Environmental Analysis has benefited greatly from the advent of GIS in that it has become much easier to organize the data required and to achieve more complex levels of analysis. However, the fundamentals of this type of analysis were in place prior to the rise of GIS as a tool in archaeology and GIS are not required for this type of analysis.

2.1.2 Prediction or Explanation

Predicting archaeological site locations as a part of cultural resource management has played a large part in North American settlement pattern studies prior to GIS (Kvamme 1995:3) and has continued to dominate settlement studies to date (e.g. Kvamme 1992, Dalla Bona 1993, 1996, Warren 1990, Hasenstab and Resnick 1990, Altschul 1990 and Carmichael 1990). Research which looks at settlement studies outside predictive models, which generally have a more utilitarian function, have been rare. Some recent research has proved to be an exception. Allen (1996) and Hasenstab (1996) have recently published settlement studies of Iroquois village sites in New York State, neither of which are concerned with producing predictive models. Instead, Hasenstab (1996:223) describes his study as "going beyond predictive modelling of site locations and attempts to use settlement analysis as a means of testing hypotheses about prehistoric culture change". This statement reveals the recognition that studies focusing on the prediction of archaeological site locations have been lacking in their ability to explain those site locations and that this is ultimately limiting to our understanding of settlement patterns. Pilgram (1987:69) has suggested that these models should have explanatory value as well as predictive accuracy. While explanation is likely a goal for most predictive models, the predictive aspect of the model is the primary goal in most cultural resource management projects.

The research for this thesis has been directed toward building explanatory models of site location on the Northern Plains for a number of reasons. The lack of such models in a North American and particularly Canadian context suggests a deficiency in research in this area. The handling of large amounts of site location data was, prior to GIS, a very difficult task. This factor has likely prevented in depth analysis of precontact settlement patterns on the Plains to a large degree. The Grasslands National Park survey, with all site locations and attributes already in a GIS format as well as having an environmental dataset, provides an excellent opportunity to analyze precontact settlement patterns as they relate to grassland environments in southwestern Saskatchewan. The development of a predictive model, at least in simple terms, might have been an option for research conducted for this thesis, but because of the nature of site distributions it is not warranted. As Adams and Filopoulos (1995:73) state: "The rule of thumb should be – if the land can physically hold a site, expect one to be there".

2.1.3 The Approach to Explanation

Generally, the approach to the explanation of site patterning in studies reviewed in this thesis has taken the form of trying to confirm or disprove previously stated hypotheses (e.g. Brumley and Dau 1988, Dreaver and Morter 1981, Dreaver 1980a; 1980b). This approach reflects the New Archaeology assertion that prediction is equivalent to explanation (Trigger 1989:301) where hypotheses which predict site distribution explain their occurrence. In more recent GIS studies, the testing of explicit hypotheses has not been very prominent with some exceptions (e.g.. Wheatley 1995, Hasenstab 1996). Few studies present specific hypothesis statements which are to be tested against the data. Rather, the approach to explanation has often been one where the results of a study are interpreted as to how they fit into previous research or ethnographic knowledge. In general, the process of regional analysis as of late has been one where:

a) The researcher selects variables which are thought to be relevant to settlement patterns based on previous research, ethnographic literature, or personal observation.
b) The researcher tests site or feature locations against these variables in an effort to identify the nature of the relationship between settlement and the selected variables.
c) The researcher may then interpret site patterning in the context of previous research, ethnographic literature or personal observation, and note where the patterns of settlement agree with or conflict with previous assumptions about settlement or past life ways.

Examples of this approach are seen in Allen's (1996) study of Iroquois sites as they relate to climate and agricultural suitability, Baena et al.'s (1995) analysis of Bell Beaker sites as they relate to raw manufacturing materials in Spain, Harris and Lock's (1996) study of the relationship between visibility on the landscape and Iron Age sites in England, and Gaffney and Stancic's (1991) study of settlement patterns and site territoriality on the Island of Hvar. More specifically, Gaffney and Stancic define three particular problem areas including: the definition of site territories, land use within territories, and factors affecting the location of sites. They then proceed to describe the approach to each of these problems (Gaffney and Stancic 1991:47-48). Importantly, the process of developing an approach is also detailed. What becomes apparent is that while the general questions in the study did not change, specific approaches did. For example, Gaffney and Stancic (1991:49-53) found that traditional circular site catchments around hillforts were not very useful in an explanatory or analytical context, but could be made to be more useful if the catchment boundaries were modified to take landscape features into account. It is this type of refinement of approach that is used in the analysis presented in this thesis.

2.1.4 Theoretical Considerations of Regional Analysis

The selection of variables and the research decisions which direct the analysis of settlement patterns in archaeology require a basis in archaeological theory. The approach taken will affect the degree to which environmental or cultural factors are used as an explanation of observed site patterns. The degree to which environmental or cultural factors affect site location patterns is currently the subject of debate by archaeologists using GIS (Zubrow 1994:108-109).

It has been argued that GIS as a technology is not theoretically neutral (Wheatley 1993). Most available data sets are environmental; this has often led to an environmental focus for research, the appropriateness of which has been questioned (Gaffney et al. 1995:211). From initial studies where patterns of site locations were largely examined in the context of environmental variables only, two major approaches have been developed. The first, largely North American approach has maintained an emphasis on environmental variables and has often been heavily quantitative. The second, largely European approach has risen as a response to the functionalist character of previous studies. It has been described as a "cognitive" approach (Zubrow 1994) and emphasizes social and cultural factors of settlement studies and particularly the impact of cultural perceptions of the environment (Wheatley 1993:735). Finally, recent studies have begun to call for a synthesis of approaches, insisting that solely 'natural' or 'cultural' approaches make for incomplete and biased analyses (Gillings 1997:3b, McGlade 1997:3).

van Leusen in Gaffney and van Leusen (1995:367) describes the first approach as being to some degree environmentally deterministic:

> We suppose that ED [environmental determinism] in its restricted sense has few or no adherents among contemporary archaeologists. However, there is no doubt that many recent applications of GIS, particularly in regional settlement location studies, reflect an ED approach to archaeological explanation.

He suggests that this is to a large degree a result of available GIS map themes; these are almost all environmental as they are largely derived from topographic maps (Gaffney and van Leusen 1995:368).

van Leusen sees different uses for the approach emphasizing environmental factors. The cultural resource management (CRM) aspect of the use of GIS in archaeology relates largely to predictive modelling. On this point van Leusen in Gaffney and van Leusen (1995:369) states:

> Because such models are aimed at the effective protection of the cultural (archaeological) heritage rather than its understanding, I have argued that a different set of rules should apply essentially sanctioning the [environmental determinism] approach for practical reasons.

Practical reasons also include limits on time and money available.

Gaffney in Gaffney and van Leusen (1995:373) criticizes van Leusen's argument that predictive models do not require explanation or understanding. It is Gaffney's position that models without explanation are not reliable and thus do a disservice to CRM. In a way, both seem to have missed the point. Archaeology without explanation or understanding serves only to conform to the minimum standard of heritage legislation. If archaeology ceases to serve explanation or understanding then it becomes merely another market driven enterprise, a service rendered so that clients conform to regulations enacted by government bureaucracy. The value of heritage resources is in what we can understand about past cultures from them, otherwise there is little reason to protect them.

This is not to fail to recognise the limitations placed on CRM projects in terms of time and money. Rather, what is suggested here is a policy of pursuing the inclusion of an adequate explanatory component for all predictive model projects. If legislator,. government policy makers, CRM clients, and the public in general can be lobbied to accept an explanatory component as part and parcel of any modelling project, then additional funds and time can be justified. Obviously things will not change over night but at the same time it is not convincing that a set of rules different than other archaeological projects should apply to predictive models.

The analysis of archaeological site patterning is another area where van Leusen suggests the environmental deterministic approach may be useful. He sees it as a method for screening out settlement patterns which relate to environmental factors, "leaving a clearer view of whatever cultural factors may have influenced the data" (Gaffney and van Leusen 1995:370). Gaffney (Gaffney and van Leusen 1995:375) points out that a distinction between environment related patterns and cultural patterns is not realistic. Gaffney et al. (1996:212) as well as Gillings (1997:3b) and McGlade (1997:3) also argue that a distinction between the natural and cultural order is arbitrary and artificial.

Alternate approaches to environmentally-based data are possible. Martlew (1997:5) sees the analysis of environmental variables as part of the investigation of possible decision processes in the location of past activities. Although it has been contended that research based largely on environmental datasets is "predicated on either an implicit or explicit environmental determinist view of culture" (McGlade 1997:2), there is nothing inherent in environmental data themselves which require them to be interpreted in this manner. Instead, the danger lies in environmental data taking "inappropriate precedence in the understanding of human societies" (Limp 1997:1).

The advocates of a cognitive approach to GIS applications in archaeology see themselves as a force in direct opposition to the "New Archaeology" which they identify with studies concerned primarily with environmental variables (Gaffney et al. 1996, Zubrow 1994). Studies which have been done by cognitive archaeologists using GIS have focused heavily on line-of-site studies on European monumental structures (e.g. Gaffney et al. 1996, Ruggles and Medyckyj-Scott 1996, Wheatley 1995). This type of study, with its specific focus on monuments in reconstructing cognitive patterns, may be lacking if both cultural *and* natural factors are not considered when looking at the locations of these monuments (Gillings 1997:3b). An attempted division of the cultural and natural would lead to the same problems as an environmentally deterministic approach .

The problem which remains is understanding the degree to which social or environmental factors affect patterns of archaeological site location. In a study of the Northwest Coast of North

America, Maschner (1996) found that beach quality, climatic exposure, cardinal exposure, and island size account for most variation in site location but not at all for site size. Maschner (1996:188) considers environmentally-based patterns to be "a screen onto which settlement patterns that might be socially or politically significant could be projected". In terms of his study data, Maschner sees site location as largely dependant on environmental variables. The intensity of occupation, however, is related to social and cognitive factors. This compares favourably with the findings of Pickering's (1994) study of physical and social landscapes of the Garawa, a Northern Australia hunter-gatherer group. Pickering collected settlement data ethnographically and, therefore, much information was available about sites which would not have been were the study an archaeological survey. At the macro-scale, Pickering found that:

> Social factors, such as affiliation to home estate, religious sites, family, friends, allies and so on, certainly strongly influenced which sites were occupied by which individuals; the locations of the sites themselves, however, and their seasons of occupation, were determined by the need to articulate the subsistence-settlement landscape with the environmental parameters imposed by the physical landscape (1994: 155).

In general, Pickering (1994:149) argues that social components of the Garawa culture, particularly their territorial boundaries, largely correspond with their subsistence-settlement system. This in turn corresponds with aspects of the physical landscape, especially drainages.

These studies suggest that while social factors are important in settlement patterns, the factors affecting the general patterns of site location have been environmental factors relating to subsistence, particularly where the economy was based on hunting and gathering. Specific site types with a lot of social significance may form an exception to this pattern. Butzer (1982:258) sums up this approach: "...site location is essentially rational, often less than optimal, and always to some degree idiosyncratic".

2.1.5 A Landscape Approach as Synthesis

Three components can be seen as essential to regional environmental analysis: the geoarchaeological, the ecological, and the social. Karl Butzer's (1982) work *Archaeology as Human Ecology* clearly illustrates the need to view the context for human settlement as the landscape, both in terms of how geological processes have shaped the remains of settlement patterns that are analysed today as well as the base from which most resources used by cultures came from.

Butzer (1982: 260) integrates a geoarchaeological approach into the analysis of site location and settlement, something which has been lacking from some GIS studies (Weimer 1995:96). This geoarchaeological approach requires that attention is paid to the taphonomic processes which selectively erode or bury the landscape, and therefore archaeological sites, over time. A geoarchaeological approach is critical to the analysis of site locations; otherwise it is not possible to distinguish patterns of site locations which relate to geomorphological changes in the landscape from patterns created by culture. Defining what is cultural and what is a geological process may be the most important distinction that can be made in the course of a regional analysis study.

The ecological landscape, or the context in which a culture bases its subsistence and shelter, is perhaps most often the focus of regional analysis studies so far. The reasons for this are numerous, not the least of which has been that the remains and evidence with which archaeologists work are most often related to subsistence and shelter, especially when looking at cultures based on hunting and gathering. Analysis using GIS brings a further emphasis on environmental variables because the initial data available for a GIS project are almost always environmental. Finally, the ecological landscape structures the distribution of shelter, food, and raw materials, particularly for groups with a hunting and gathering economy (Pickering 1994:157). The spatial distribution of these resources in turn imposes limitations on where sustainable human settlement can occur.

Thirdly we have the social landscape. Of the three, this is often the least quantifiable. As GIS requires a specific location with an associated value or class to create a map theme, the analysis of patterns of features or sites as they relate to social aspects of a culture has not always been straightforward. It is possible to some degree to anticipate patterns related to social interactions between groups where these involve things like trade or boundaries. The symbolic aspect of spatial patterns, however, is related to the workings of the human mind where symbols and perception give structure. In this case, patterns are not easily predictable or possible to anticipate as they are not bound to physical landscape to the degree that the economic aspects of human culture are. What makes analysis of this kind possible is an interpretation of the environment which seeks out areas of defined symbolic nature. Understanding the area overseen by a monument like a medicine wheel or a henge, for example, may provide some clues to the symbolic nature of that monument.

The ideal regional analysis is a synthesis of all three landscapes: the geoarchaeological, the ecological, and the social. An understanding of the geoarchaeology of a region directs the archaeologist to areas where sites or features may have been eliminated, possibly creating an apparent pattern. The ecological and the social landscapes combine to account for the remaining patterns evident in the record. Their interpretation becomes most useful when it is possible to take into account the possible effect one landscape may have on the workings of the other. Patterns of site location can and do centre on sites which are significant from both a social and ecological perspective. When taken together, these landscapes provide a holistic view of human interaction with the environment in which they live.

2.2 Settlement Studies on the Northwestern Plains

A review of settlement studies on the Northwestern Plains is essential for this type of analysis. Studies of settlement have generally taken two basic approaches. One is to gather together information about settlement patterns from site specific sources and infer patterns of site location about specific archaeological cultures. The second is to derive information about settlement patterns from regional surveys.

Patterns of site settlement inferred from site specific sources tend to be general as they are usually a part of a general survey of archaeological cultures in a given area. Often, a description of settlement patterns associated with archaeological cultures is entirely left out of regional overviews (e.g. Frison 1991, Dyck 1983). Reeves (1983), however, provides some basic comments on patterns of settlement in the last 2000 years. For instance, the main trend he sees for the Pelican Lake culture is the preference for stream terraces or rock shelters for habitation. Pelican Lake tipi rings may be located at the prairie level or on high terraces (Reeves 1983:87). For the Besant and Avonlea complexes, stream terraces appear to be the preferred location for habitation sites (Reeves 1983: 97, 105). For later cultural groups, habitation sites are most often found on stream or river terraces as well as in caves (Reeves 1983: 305, 306). What is apparent is that these site location patterns most likely reflect the sample of sites used by Reeves in his study and do not particularly reflect the general trends of settlement for these cultural periods. Foor (1982: 184-185) also provides some comments on settlement patterns concerning the Pelican Lake cultural complex. He divides habitation sites into two categories, winter and non-winter. Winter habitations were large sites, sheltered, and adjacent to permanent water sources. Non-winter habitations were located on higher, more exposed terraces or in caves. Descriptions of settlement patterns at the level of archaeological cultures are problematic in that archaeological cultures on the Plains are usually dispersed over a wide area, which means that descriptions of settlement patterns over the landscape have to be general in nature. In addition, it is difficult to account for survey bias at this level as it is impossible to know if different landforms or regions have been subject to more survey than others.

Regional surveys are the most common approach to settlement questions. Generally, a geographic area of interest is selected and systematically surveyed so that specific research questions can be answered. The purpose might be purely for research purposes or it may relate to how development impacts archaeological resources in a region. The specific aim of studying settlement patterns is not always the primary aim of the survey. Sometimes surveys are conducted to document a large number of sites in a given region and to provide greater resolution to the culture history of that area. Studies of this nature in the general area of and similar environment to Grasslands National Park include studies in Montana (Dreaver and Morter 1981, Dreaver

1980a, 1980b, Davis 1975), in Alberta (Brumley and Dau 1988, Adams 1976) and Saskatchewan (Adams and Filopoulos 1995, Dalla Bona 1993). The locations of these studies are shown in Figure 2.1.

Surveys in Montana, when addressing settlement patterns, have tended to compare site locations with specific landforms. In a survey of the Frenchman Creek (the Frenchman River in Canada) and Milk River areas, Davis (1975) recorded 63 sites. The research design was not set up with the study of settlement patterns in mind; therefore only a few pieces of information can be

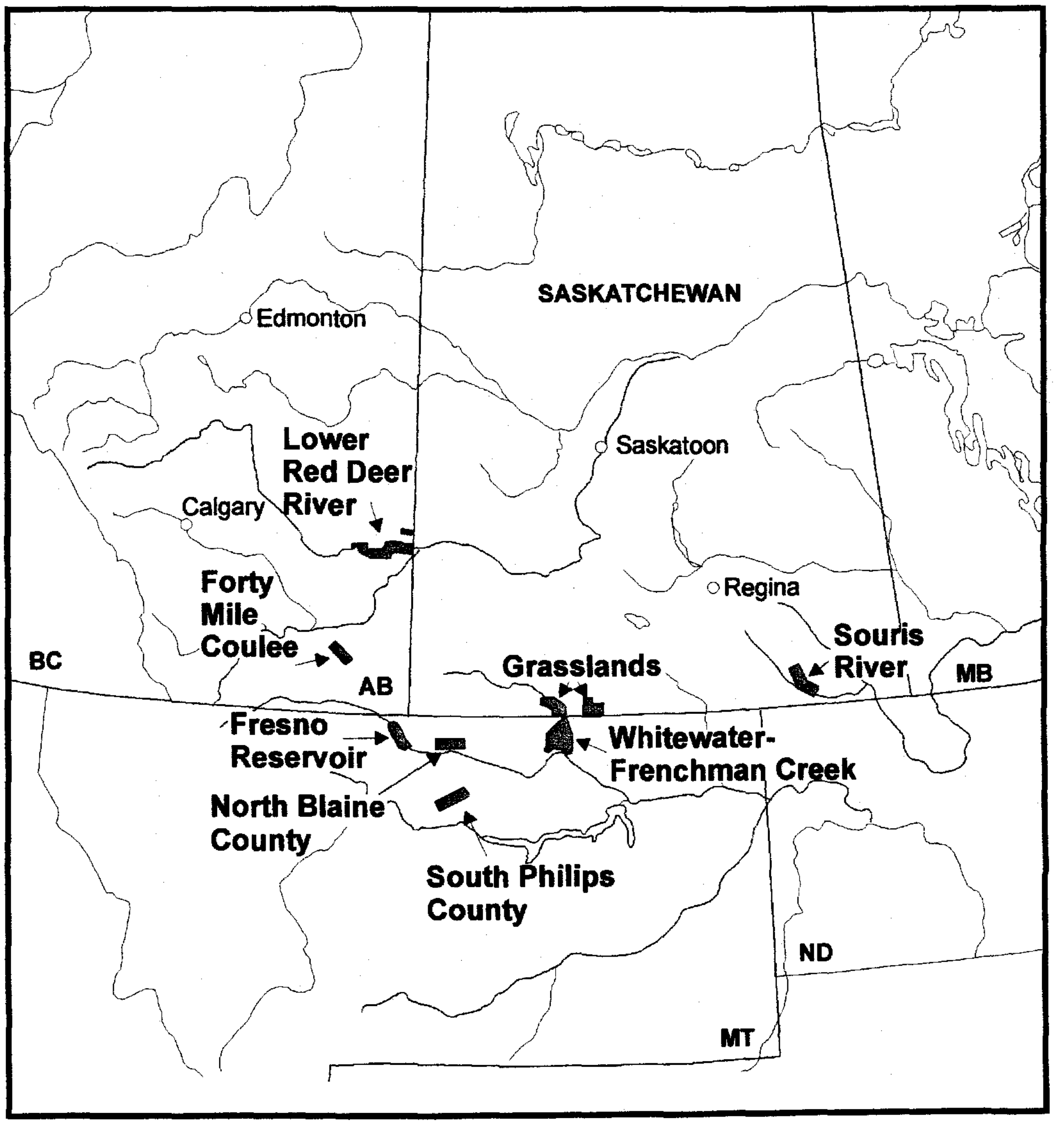

Figure 2.1 Locations of the Surveys Discussed in Chapter 2.

put together towards this end. When tabulated from Davis' report on the survey, most sites that were recorded were located on the valley rim with fewer sites in the floodplain and open prairie (1975:73-84). Unfortunately, no real inferences can be made from these data as there is no record of the proportions of the types of landforms that were surveyed and thus the settlement pattern implied could be the result of the amount of attention particular landforms received during the survey.

Dreaver (1980a, 1980b) conducted surveys of Bureau of Land Management lands in North Blaine and South Phillips counties, Montana, which are adjacent to the Canadian border. This was followed by a survey, using essentially the same methods, of the Fresno and Nelson Reservoirs which are located in the same area (Dreaver and Morter, 1981). In these cases, survey objectives were much more focused on settlement patterns and the information collected was appropriate for this type of analysis. The above surveys used a set of standardized landscape definitions which were compared with the distributions of sites, the size of sites, and the distribution of features in order to seek patterns of site distribution. In the case of the North Blaine and South Phillips County surveys, upland areas consistently had higher densities of sites and features (Dreaver 1980b: 10.18). These upland areas are flat to slightly rolling with short grass vegetation. Water is scarce, as are wood and food plants (Dreaver 1980b: 4.4). Lowland areas show lower densities of sites and features in general, with some specific exceptions. The problem with these results is that a disproportionately greater area of the uplands was surveyed with only a small portion of the lowlands included. This was partly due to the fact that the Bureau of Land Management lands most often included uplands and partly that much of the lowland areas had been cultivated and would not have produced a comparable sample of sites to uncultivated areas (Dreaver 1980a: 8.4).

The survey of the Fresno and Nelson Reservoir areas produced similar results to the surveys of the North Blaine and South Phillips county areas, where upland zones had higher site densities and higher feature densities than lowland areas (Dreaver and Morter 1981: 6.30). Dreaver (1980a: 9-14) recognizes a contradiction in his survey results in that:

> The prehistoric inhabitants needed the stones and game herds present in the uplands, but they also needed the water and plant resources that the uplands lacked.

The fact that many sites lack a proximity to water in this dry environment is troubling. Activities appear to have been located near seasonal water sources when it was available. Dreaver (1980a: 9-14) suggests that it may have been easier to frequently haul water over a distance than to transport animal carcasses over a distance.

Dreaver (1980a: 9-15) sums up the pattern of land use apparent from his surveys in this way:

> It appears that the prehistoric inhabitants moved to the type of terrain with the resources that they sought, and then stayed there until their needs shifted. They were willing to make fairly long forays to other types of terrain to obtain necessities, rather than move constantly.

Two surveys in Alberta are relevant for this study; a survey of the lower Red Deer River (Adams 1976) and the Forty Mile Coulee Reservoir (Brumley and Dau, 1988). It is worth noting that like many surveys made on the Plains, the focus of the study area was a specific drainage system. This focus tends to bias interpretations of past land use towards patterns associated with these drainages. The focus on drainages is often unavoidable, however, as land away from drainages has often been cultivated, with many of the more visible archaeological features relevant to the analysis of settlement pattern having been destroyed.

Adams (1976) noted a number of trends in the patterning of sites along the lower Red Deer River. This survey was located along the Red Deer River, west from the Saskatchewan-Alberta border. Sites and feature types were compared to a number of variables, including landform, distance from water, vegetation, ungulate habitat, and availability of shelter (Adams 1976:133-135). As was noted for surveys in Montana, access to permanent water does not seem to have been paramount in site location with only 10.6 % of sites located near permanent water. Conversely, only 18.5 % of sites had no water within 1 km suggesting that seasonal water sources were a significant resource (Adams 1976:93). Another association that was noted was between sites and areas with good potential for ungulates with 84.4 % of sites located in the winter ungulate range (Adams 1976:94). Shelter played a lesser role with most sheltered sites protected from the north or west winds. Finally, a division by landscape was noted. The vast majority of sites were located on the prairie or terraces not on the floodplain or coulee bluffs (Adams 1976:93).

In considering the main force ordering site location in the survey area, Adams (1976:108) states that "rather than select for individual resources the prehistoric populations chose locations on the basis of the greatest number of required resources within a limited area". Because the majority of sites were located within 1km of river bluffs, they would have access to the water and plant foods of the bluffs and to the game animals on the prairie above (Adams 1976: 111). Thus the picture is one where we find people trying to find a place in the landscape which is not too far from any given resource.

A second Alberta survey with a bearing on Plains site settlement patterns was conducted by Brumley and Dau (1988) at the Forty Mile Coulee Reservoir in southeastern Alberta. An in-depth description of settlement patterns evident in the survey is not given. Instead, the survey was interpreted within the context of a pre-contact settlement model for southeastern Alberta which is presented in the survey report. This model was used to assign a predefined natural and cultural context to the landscape of Forty Mile Coulee from which research questions about culture history, cultural activities as represented in artifact assemblages, and the structure of stones circles could be derived (Brumley and Dau 1988: 97-100). Unfortunately, the source data from which the model was derived were not discussed.

The settlement model for southeastern Alberta presented by Brumley and Dau (1988:78-84) focuses primarily on the location of bison and terrain associated with hunting, lithic resources for stone features and tools, floral resources, and fuel resources. Within the model, bison hunting is considered the primary factor on which settlement was based:

> Although a very diverse range of floral and faunal resources were exploited by historic and prehistoric groups in the area, bison was the focus of subsistence activities. Bison procurement is considered here the primary activity around which other aspects of aboriginal life were largely structured (Brumley and Dau 1988:78).

The model as presented by Brumley and Dau (1988) describes site patterning as it relates to six ecozones in southeastern Alberta, three of which relate to Grasslands National Park. The first is the Major River, Stream and Coulee Systems Zone. Within this zone, a wide variety of sites are noted for southeastern Alberta, including camps, bison kills and processing sites, as well as ceremonial sites. This zone is considered to have been important because of the variety of resources which would have been available. Large valley bottoms have buried sites with site density increasing toward the base and slope of the valley walls. Finally, "The greatest density and diversity is found on the prairie surface along the valley margins…" (Brumley and Dau 1988:90-91). The Open Level to Gently Rolling Prairie Zone is classified as having a very low archaeological site density due to only seasonally available water and poor topography for hunting. Finally, the Open Moderately to Strongly Rolling Prairie Zone has a high density of archaeological sites, primarily stone circles, cairns and alignments, which are thought to be associated with short occupations by smaller groups (Brumley and Dau 1988: 92-93).

The final part of this section will look at relevant surveys done in Saskatchewan. The first is a survey of a section of the Souris River done by Luke Dalla Bona (1993). Prior to the completion of the Rafferty Dam reservoir in southeastern Saskatchewan, an archaeological assessment of the area was carried out. In conjunction with this project, the Saskatchewan Research Council funded a survey of 25 square kilometres by Dalla Bona for the purposes of developing a predictive model (Dalla Bona 1993:54). In the process of developing this predictive model, Dalla Bona looked at a number of environmental variables as they related to the location of archaeological sites and features. He used the same single sample chi-squared test used in most of the analysis done for this thesis. Cairn sites (n=18) showed no particular affinity for any environmental theme (Dalla Bona 1993:113-116). Stone ring sites (n=33) showed an association with areas 0-800 metres from a permanent water source. Dalla Bona does not include an association between ring sites and prairie edge as being statistically significant, however, a recalculation of the chi-squared statistic shows a statistically significant association between stone rings and prairie edge. Indeed, Dalla Bona (1993:121) identifies locations 400 metres from a permanent water source and locations less than 250 metres from the prairie edge as areas where stone rings are most likely found.

Dalla Bona (1993:129) suggests that the location of cairns reflects an effort to "maximize their visibility from either prairie level or from down in a coulee bottom". Problematic for his study was the fact that his digital slope data were not detailed enough to permit a finer resolution analysis. Stone rings sites situated near permanent water sources would have been able to take advantage of drinking water, plant foods, and other resources associated with permanent water. A prairie edge location for stone ring sites would have been useful for monitoring game in both the valley bottoms and the prairie uplands (Dalla Bona 1993:130).

The results of the Grasslands National Park (G.N.P.) archaeological survey as presented by the original investigators will be considered in some detail (Adams 1986, Adams and Filopoulos 1995). The context and environment of the G.N.P. survey are dealt with in detail elsewhere in this thesis. The primary researchers on this project were Gary Adams and Peter Filopoulos of the Department of Canadian Heritage.

Adams (1986:20) observed after the first year of survey that:

> ...there has been very little soil development over major portions of the study zone. This factor has resulted in the vast number of the sites retaining some surface visibility.

The fact that specific consideration was given to site visibility as affected by soil deposition assists in the interpretation of further patterns of site location. Issues of soil deposition and erosion will be dealt with in greater detail later in this thesis. Essentially, there is no landform in G.N.P. where there is not at least some degree of site visibility.

According to Adams and Filopoulos (1995:73), a critical factor in considering site location in G.N.P. should be the availability of water. Problematic is the fact that patterns of site location do not relate directly to the location of water. The association of sites with seasonal potholes and coulee rims is evident, but many coulees would only have flowing water in early spring or after a thunderstorm. Adams and Filopoulos (1995:74-75) suggest that some of these sites might reflect the ability of people to extract water from wet soils, and this was observed by Mathew Cocking while travelling on the plains of Saskatchewan in 1772-73 (Burpee 1908:108). Sites are noted far away from water sources on the open prairie, but these tend to be small and were likely short term occupations. A lack of high resolution mapping of the water in G.N.P. hampers analysis of site location in relation to this resource.

Faunal and floral resources are also identified as a major factor when considering site location patterns, particularly bison. Adams and Filopoulos (1995:77) anticipate that bison would be available throughout G.N.P. area for most of the year while in winter the bison would be mainly be limited to the Frenchman River Valley. The many drive line segments mapped in G.N.P. suggest that the Park area was used intensively for communal bison hunting, likely in the fall. The direction of these drive lane segments suggests that the Frenchman River Valley may have been a destination for intensive bison harvesting at this time. Drive line segments also appear to have a higher intensity of land use associated with them, even incorporating stone ring sites as a part of the lane (Adams and Filopoulos 1995:86).

A number of resources were identified as important without making reference to specific site patterning. Floral resources are likely important but would require additional mapping to identify site patterning associated with them (Adams and Filopoulos 1995:81). Shelter is also thought to be important in site patterning, especially in winter. On the other hand, open areas may have been valued for the view afforded by them as well as wind to drive insects away (Adams and Filopoulos 1995:81). Finally, fuel for fire would have been important. While wood is rare, Adams and Filopoulos (1995:80) suggest that because of the density of bison that would have been in the area, bison dung would have sufficed for much of the fuel needs.

2.3 Grasslands National Park Within the Seasonal Round

Understanding the place G.N.P. occupies within the seasonal round of precontact bison hunters is essential for understanding what types of sites might occur in the Park as well as providing a context for the interpretation of site and feature location patterns. This section will review current ideas on the seasonal round followed by precontact hunters on the Canadian plains and attempt to establish the place G.N.P. occupied within that round.

2.3.1 The Seasonal Round On the Canadian Plains

Both historically and archaeologically, groups living on the Canadian plains depended on bison as a primary sources of food and raw materials (Arthur 1975; Verbicky-Todd 1984; Wright 1995). This reliance on bison required that groups follow or anticipate the movements of the bison throughout the year (Gordon 1979; Graspointner 1980; Morgan 1980). Thus the seasonal round undertaken by bison shaped the seasonal activities of the Native peoples who inhabited the Canadian plains.

While some maintain that bison "wandered erratically" in their movements (Verbicky-Todd 1984:4), most researchers are of the opinion that bison movements were to some degree predictable from year to year and that precontact groups were aware of these movements (Arthur 1975:107; Gordon 1979:38; Graspointner 1980:91-94; Morgan 1980:145; Wright 1995:315). In general, the bison inhabiting the Canadian plains are thought to have moved between winter and summer ranges (Morgan 1980:152; Gordon 1979). Major factors contributing to the seasonal movements of bison includes the availability of water; shelter when required, and particularly good quality forage (Morgan 1980; Brumley and Dau 1988:78; Frison 1991:9-10).

The following description of the seasonal round is from Morgan (1980:150-155) and is used here because its ecological approach can be related to the GIS analysis of sites in G.N.P. The description emphasizes the Canadian plains in general and Saskatchewan specifically. Bison began to move out from the parkland edges into the surrounding mixed prairie in the spring. Forage capacity by the end of April was very high in the surrounding prairie stimulating this movement. In Saskatchewan, bison likely moved into their summer range in the south and western parts of the province in May. These movements coincided with the new spring growth of blue grama grass in these areas which occurs later than most other grasses. As modern bison follow well defined paths between summer and winter ranges, Morgan (1980:152) suggests that historic bison in Saskatchewan congregated on major north-south trails during movements from winter to summer ranges. Summer ranges had relatively low productivity compared to winter range grasses. This required bison to separate into smaller nomadic herds which dispersed over a large area.

Bison then congregated once more for the rut which can occur anywhere from July to October, depending on the herd location (Tesky 1995). After the rut bison once again dispersed but congregated on trails going north to their winter range (Morgan 1980:153). Bison began their northward movements because grasses in the southern range have cured by the end of July, losing their nutritional value. The grasses of the mixed prairie bordering the parklands were still partially green. Water is also scarce on the southern grasslands at this time. By the latter part of October few if any bison remained in the southern grasslands. Bison wintered in the parklands and major river valleys where good forage was available as well as shelter from harsh winter conditions. Winter herds tended to be large and were relatively sedentary for large parts of the winter (Morgan 1980:152).

Gordon (1979) mapped bison movements through historic accounts and these movements generally correspond to those proposed by Morgan (1980). Gordon included regions like the Cypress Hills and Wood Mountain as areas where smaller herds or sub-herds would winter (Gordon 1979:22). A number of factors could divert the bison from their regular seasonal round. Mild winters could cause bison to stay out on the plains longer than usual (Arthur 1975:54; Verbicky-Todd 1984:6). Other disruptive factors could include burned over grasslands and locust infestations (Wright 1995:315) and in general bison movements were subject to the condition of forage (Frison 1991:9).

The seasonal round followed by Native people has been subject to some debate. Graspointner (1980) studied the ethnographic and historic accounts of the seasonal round of the Blackfoot and the Atsina (Gros Ventre) in southeastern Alberta. According to Graspointner (1980:91-94) the Blackfoot and Atsina wintered in band-sized semi-sedentary camps along major wooded valleys near water. While the Blackfoot used bison pounds to obtain meat in the winter, the Atsina would hunt game "on an individual level" (Graspointner 1980:91-92). In the spring the Blackfoot would disperse onto the plains but gather together in large groups for summer ceremonies while the Atsina would gather in April for a spring hunt and would stay together for the summer (Graspointner 1980:19-93). In the fall both the Blackfoot and Atsina would separate into bands to acquire meat provisions for the winter (Graspointner 1980:92-93).

The idea that fall communal kills were used to procure large amounts of meat for use during winter has been a topic of some debate. Citing historic accounts, Arthur (1975:99) notes that communal bison hunting occurred throughout the winter. If this source of food was available, he argues, then large quantities of dried meat provisions would not be required for the winter (Arthur 1975:106). Hjermsted (1996:254-255) notes that a number of pound or jumps known from the archaeological record in Alberta, Saskatchewan, Wyoming and Montana were used during the winter or early spring. Communal hunting sites for the summer were comparatively rare, which lead Hjermsted (1996:255) to conclude that communal hunting occurred from late fall to early spring. Reher and Frison (1980:43-44) maintain that stored meat provisions would still be required for periods when bad weather limited movement and hunting. While it is clear that many wintering groups camped by a bison pound or jump (Arthur 1975:107; Graspointner 1980:92; Verbicky-Todd 1984) it is not clear if this was the pattern for all groups. If hunting was carried out by some bands on a more individual level during the winter, as Graspointner (1980:93) notes for the Atsina, some dried meat stores may have been required for the harsher parts of winter.

2.3.2 Grasslands National Park Within the Seasonal Round

The ecology of G.N.P. provides some evidence as to how the Park fits into the seasonal round of bison herds and the people who hunted them. The West and East Block of the park have different characteristics and may not have been used equally throughout the seasonal round. G.N.P. falls within the summer range for bison defined by both Morgan (1980) and Gordon (1979). Morgan (1980:152) notes that bison movements onto their summer range coincided with the emergence of blue grama grass. Blue grama is a dominant grass in G.N.P., particularly in the upland areas of the West Block and over much of the East Block. Blue grama grass begins its growth in May or June with the onset of summer rains (Tirmenstein 1987). These factors suggest that bison began major movements into the Park area about this time. Surface water would have been available during May and June but largely dries up in July and August. It seems probable that some communal hunting would have occurred in the Park at this time (Adams and Filopoulos 1995:83). Hjermsted (1996:255) notes archaeological evidence of communal hunting in the spring in Alberta and Wyoming and Graspointner (1980:92) notes that the Atsina engaged in a spring communal hunt.

Summer use of the G.N.P. area would certainly have been possible but subject to a number of limiting factors. Much of the surface water in the area dries up by July and August, leaving water mainly in the Frenchman River in the West Block and in Rock Creek in the East Block. Adams and Filopoulos (1995:84) suggest that Native groups would have located themselves on landscape edges near water sources. Forage in the bison summer range is low in productivity which would have required bison to form small nomadic herds dispersed over a large area (Morgan 1980:152). During mid summer, small herds of bison may have grazed the grassy uplands in the Park, occasionally moving to creeks and the Frenchman River for water. Because of the dispersed nature of the bison, communal hunting may have been relatively rare at this time. This is in line with the findings of Hjermsted (1996:225) in a review of the seasonality of archaeological communal hunting sites on the Northern Plains. Verbicky-Todd (1984:5) suggests that Plains groups may have used bison hunting techniques like the surround when bison driving was not a viable option.

Both the West and East Blocks of the Park have areas which may have been used during the season of the rut, which likely ranged through July and August (Arthur 1975:106) although based on observation of modern herds the rut could have begun as early as June (Tesky 1995). Gordon (1979:36) places the rut outside the Park area on the mesic mixed grassland, which Morgan (1980:147) maps as lying to the north of the South Saskatchewan River and east of Wood Mountain. Other sources do not refer to the rut as occurring within a specific grassland environment. The quality of grasses has been noted as a significant factor in determining bison movements (Morgan 1980; Frison 1991:9). It would follow that if the grasses within G.N.P. were capable of supporting the large herds of bison during the rut, the bison would likely have been present. The large number of bison would have supported communal bison hunting. Adams and Filopoulos (1995:84) feel that the series of bison drive complexes along the Frenchman River Valley were used intensively during the fall.

Winter use of G.N.P. seems likely in some areas but not for others. Bison are noted to have wintered in river valleys (Verbicky-Todd 1984:6; Frison 1991:11) in order to gain shelter from harsh winter conditions. Similarly, Plains groups were known to winter in river valleys because of the availability of bison and other game, shelter, water, and winter fuel (Graspointner 1980:94; Brumley and Dau 1988:91). This raises the possibility that the Frenchman River Valley in the West Block was used as a wintering locale for both bison and people. Adams and Filopoulos (1995:83) feel that the entire Frenchman River Valley could have been used as a wintering location, because it provided shelter and habitat for game. A herd of 200 antelope has been reported to winter in the valley northwest of the Park area (Dirschl 1961:13). However, not all parts of the valley may have been equally suitable for wintering. Much of the Frenchman River Valley in the West Block is wide, poorly wooded, and has patchy grasslands due to clayey and saline nature of the soil (Bookbinder 1992:106). This environment would seem less than ideal for feed or shelter. The portion of the valley which runs along the western edge of the West Block is narrower, has greater surface moisture and is more densely wooded than other parts in the valley. These conditions may have made it a wintering location. The East Block is largely made up of open grassy areas without much shelter so it seems unlikely that bison or people wintered there. The northern edge of the East Block includes the edge of Wood Mountain and has numerous wooded drainages interspersed with grassy areas. This part of the East Block could have provided the shelter bison required for a wintering location as well as fuel for people who hunted them. Charles Larpenteur (1989:162) traded with Crees at a camp at Wood Mountain during the winter of 1842. Larpenteur remained at the camp for six weeks during which time it had not been moved. As Wood Mountain was used as a wintering locale historically, it is likely that it was a suitable wintering place in precontact times.

In effect, Grasslands National Park provides a range of environments which may have been occupied year-round by groups in precontact times. Seasonal differences in climate and water availability would have created a situation where different environments within the Park were used at different times of the year.

3.0 Data Sources and Acquisition

The GIS data for this research come from three basic sources: the archaeological survey, GIS environmental themes owned by G.N.P., and from remote sensing data. The following is a discussion of how these data were derived and what considerations may be necessary when using them for analysis. For the purpose of this discussion map themes are defined as maps which represent only one type of information (e.g. an elevation map without water, roads, or any other type of information on it).

For the purposes of this study, all maps themes used the Universal Transverse Mercator, Zone 13 projection, and the 1927 North American Datum. This was in keeping with the original topographic map themes for this area which follow this format.

3.1 The Grasslands National Park Archaeological Survey

The purpose of the archaeological survey was primarily to identify cultural resources (in other words archaeological sites) which may need to be protected from damage by park visitors or environmental forces such as erosion. The survey consisted of five field seasons and was conducted by Canadian Heritage, Archaeology Department staff members Gary Adams and Biron Ebell in 1985, and by Gary Adams and Peter Filopoulos from 1991 to 1994. The survey also had volunteer members in 1992 and 1993. The survey was designed to record the specific site location, area, elevation, known occupations, presence of tools, bones, tipi rings, and environmental information of sites in the park. Sites are defined as "evidence of human activity that is either a minimum of 100 metres away from its nearest neighbour or is separated from that neighbour by a significant change in topography" (Adams and Filopoulos 1995:5). Single finds are not recorded as sites. One volunteer imparted to me the survey's general rule: "A fortuitous flake does not a site make" (J. O'Neil Personal Communication 1998). Artifacts were not collected unless they were diagnostic or of particular value for future reference. In total, over 3000 sites have been recorded for the park area.

Sites were mapped onto airphoto mosaics in the field. At this scale, it was possible to record the area and shape of each individual site. The sites were later mapped onto 1:50 000 topographic maps and their positions were recorded using the Universal Transverse Mercator, zone 13 grid, 1927 North American Datum. The resulting locations are regarded as accurate to within 50 meters of the actual site location.

Theoretically, the survey was designed to cover all land equally. In practice, this was not always the case. Terrains considered to have low site location potential were not fully covered, although routine spot checks were conducted for all areas. Table 3.1, after Adams and Filopoulos (1995:4), shows the estimated percentage of sites located by landform type. Percentages are the proportion of the total number of surface sites associated with a particular landform which are estimated to have been recorded by the surveyors.

Table 3.1. Estimated Percentage of Sites Located for Given Landforms

Percent of Sites Located	Landform and Site Types
80-90%	Surface sites on linear features such as coulee rims, slough shores, ridges and valley rims
65-75%	Surface sites in the remaining portions of the park
90-95%	Large surface sites including all major bison drive complexes
25-50%	Surface sites in low potential terrains such as slopes, the bottoms of small coulees, and heavily vegetated riverbanks

Adams and Filopoulos (1995:4) describe areas of bias in the survey:

> In practice, low potential lands such as slopes, the bottoms of small coulees, and heavily vegetated riverbanks were not well covered. However, no type of terrain was ignored and routine spot checks were conducted on the most inhospitable of locations. This survey design has resulted in a somewhat biased, though still highly productive pattern.

The survey was designed with archaeological resource management in mind. This meant that the object of the survey was to locate as many sites as possible while covering the largest area possible. In practice this meant that areas that the surveyors considered likely to have archaeological sites were given particular attention (like ridges, landscape edges and sloughs). This is bias is illustrated in Table 3.1 above. However, the survey was conducted one quarter section at a time which prevented any large area from being excluded from the survey. Within the analysis of this study site associations with landscape edges will have to be interpreted in the context of the particular attention paid to these landscape features during the survey. The final result of the survey was that a body of data providing locations for most surface sites in the Park was collected.

3.2. Aspects of the Archaeological Record Represented by the Survey Data

The sites recorded within the Grasslands survey are dominated by a number of feature types. Stone ring sites or tipi rings are very numerous, as are sites with lithic scatters, concentrations of fire-cracked rock, and cairns. To a lesser degree hearth features and bison drive lanes are also common. Some of these features have been observed to be more common within certain time frames than in others. Frison (1991:92) observes that ring sites first become a regular part of the archaeological record during the Middle Prehistoric Period, or about 5000 years B.P. It seems likely that given the large numbers of ring sites found during the survey, the site patterns represented probably date from this period and later.

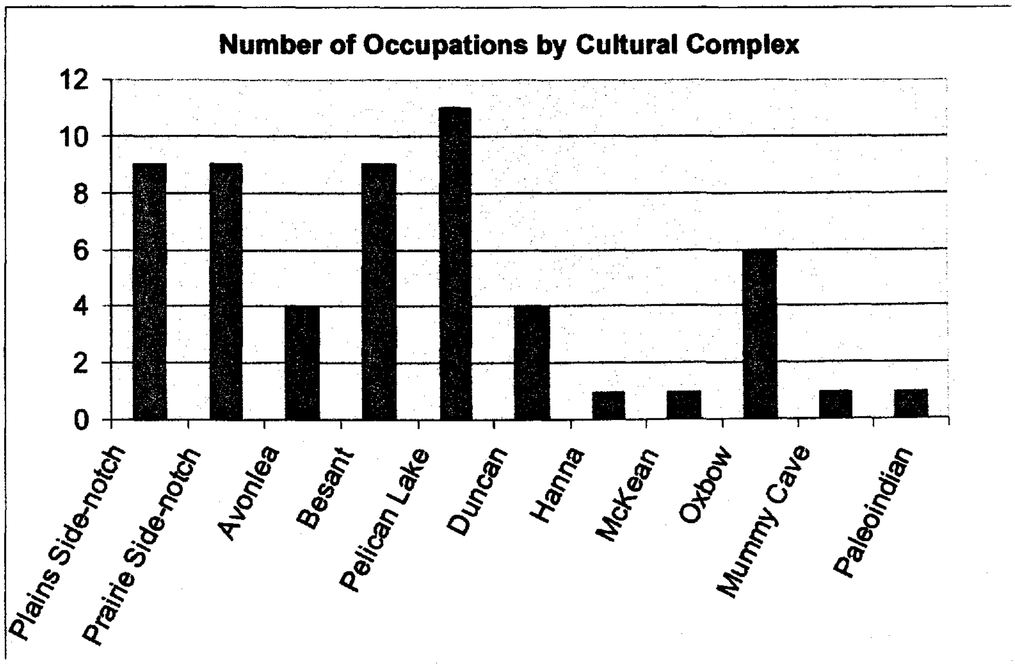

Figure 3.1 Frequency of Identifiable Occupations by Cultural Complex.

Artifacts diagnostic of a particular cultural complex also give some insight into when the Park area was used and by whom. Projectile points were the most common diagnostic artifact recovered with 69 points recovered that could be assigned to a specific cultural period (Adams and Filopoulos, 1995:62). The following is a chart which tabulates the number of sites attributable to a specific cultural complex, based on projectile points. (Figure 3.1). The pattern apparent indicates that most of the occupations are attributable to the Pelican Lake complex or later complexes (72 percent of sites with identifiable cultural complexes). If one looks at the frequency of projectile points and not occupations, the emphasis on later cultural complexes is increased. If the number of occupations by a given cultural complex is an indicator of the intensity of the use of an area, then most of the observable patterns of site and feature location within this research relate to the Pelican Lake complex and later complexes. Dyck (1983:105) assigns dates of 3300-1850 B.P to the Pelican Lake complex. In sum, the information which is apparent from projectile points seems to indicate that most of the sites recorded within the Park were created in the last 3000 years. Some other factors may also be relevant to the observed pattern. The number of sites with a cultural affiliation is unfortunately small, which means the above results may not be representative of the larger body of sites. Similarly, forces of erosion may have differentially destroyed or buried sites of particular cultural complexes providing a skewed sample of sites attributable to a particular cultural complex. Despite these issues, the available data fit relatively well into a dominant time frame of 3000 B.P to protohistoric times for patterns of site location observed within the Park.

A possible contributing factor to this pattern is that all sites recorded in the survey are surface sites. The Canadian Heritage mandate in surveying the Park did not include any excavation. This focus on the surface sites would tend to emphasize more recent occupations which would be less affected by destruction or burial due to erosion. Another effect of a surface only survey is that sites with more visible surface features would tend to be found more often than sites without these features. Obviously sites with stone features like rings sites, cairns, bison drives, and fire-cracked rock would be more visible in a prairie landscape than would small lithic scatter sites, ceramic sites, or sites with bone. In a test of survey methods which looked at artifact visibility, Wandsnider and Camilli (1992:176-180) found that artifact tone, colour, and size contributed to differential recovery by surveyors. These factors would tend to emphasize the biases noted above.

To summarize, the archaeological survey of the Park most represents sites which are likely less than 3000 years old and sites which have a high degree of visibility, especially tipi ring sites, sites with cairns, large lithic scatters, fire-cracked rock scatters, and bison drives. This in turn emphasizes the activities associated with these types of sites, most prominently habitation, boiling water for various activities, and bison hunting.

3.3 Environmental and Other Data Sources

This section will briefly describe the baseline data used in the research as well as discuss some of the issues regarding the accuracy and reliability of various data themes. The data used in this research comes from a wide variety of sources and the way various map themes were created has a bearing on the conclusions that can be reached when they are used in an analysis.

3.3.1 National Topographic Series Data and DEMS

The Canadian government provides digital maps which are derived from the original 1:50 000 and 1:250 000 scale National Topographic Series paper maps. Grasslands National Park acquired digital 1:50 000 topographic maps which the Park allowed to be used for the purposes of this research. When in a digital format, these maps are divided by theme or layers so that contour lines, hydrology, roads, and cadastral information are mapped separately. Only the hydrology and contour line themes were used for the purposes of research.

Contour lines by themselves do not provide a basis from which analysis can proceed; they only provide a visual reference of what the topography of an area is like. What is required is a map which provides continuous values of elevation throughout the study area. These types of maps, called Digital Elevation Models or DEMs, have to be computed by interpolating the values between contour lines or data points of known elevation.

In the case of the Park area data, DEMs were computed using SURFER version 5.0.2 for Windows as well as using a module in the IDRISI GIS version 4.1. To create a DEM in SURF-ER, the nodes on the contour line vectors had to be converted into point data. This required that a special program be written (in C++) for this purpose. Once this was accomplished, SURFER's minimum curvature interpolation method was used to create a 30 metre resolution DEM for both the West and East Blocks of the Park. Some errors were noted, particularly in the West Block. Specifically, SURFER interpolated pits in the valley floor which did not exist. This is the result of the tendency of the minimum curvature interpolation method to extrapolate values beyond the original data. Carrara et al. (1997:466) performed an evaluation of techniques used to create DEMs. They found that none of the techniques they evaluated could create a DEM of a flat river valley bottom with steep walls (like the Frenchman River Valley) without producing errors. Thus this problem is not so much a matter of the program used to create the DEM in this case as the difficulties in modelling the terrain particular to the Park. IDRISI was used to interpolate a DEM using only the contour lines for the valley floor. This produced a DEM without pits in the valley floor, but other less serious linear errors were created. Finally, the valley floor DEM created by IDRISI was placed over top of the original DEM created by using SURFER and filtered to produce a continuous surface.

The DEMs in the West and East Block still suffer from a number of problems which can affect analysis in varying degrees. In this case, the fact that the DEMs were calculated based on contour lines and not dispersed data points has resulted in DEMs where the contour lines are emphasized above other areas in the DEMs. The result is that the DEMs have a sort of a "stepped" character which cannot be completely removed through smoothing filters. For the purposes of analysis, the DEMs were simplified into eight elevation classes. Care was taken not to place class boundaries where data within the DEM was "stepped". Where the stepping does have an effect is on datasets which are derived from the DEMs.

An error particular to the West Block DEM is the artificial flattening of the valley to some extent due to the efforts to eliminate the pits which were created in the first DEM. In addition, IDRISI added some linear features to some areas of the valley which could not be eliminated through smoothing filters. Once again, dividing the DEM into elevation classes tends to remove the effect of these errors. In the cases of an analysis of aspect and site location, flat areas are likely over emphasized and this has to be taken into account in the interpretation of results.

3.3.2 Derivatives of DEMs

Derivatives of DEMs are map themes which use the DEM as the base for their calculation. Map themes like slope angle and aspect are common derivative maps from a DEM. In this case, the slope map themes were originally created from the DEMs discussed above. This produced slope maps of poor quality, as the "steps" created by the contours in the DEMs tended to have higher slopes than actually exist, while the areas between contour lines had lower slopes. This led to a situation where the contour lines used to create the DEMs were often visible in the slope maps. Fortunately, reliable maps of slope angle classes already existed as part of the digital maps received from G.N.P., and it was possible to conduct an analysis on slope without any problems. The aspect maps derived from the DEMs were not affected by the stepped nature of the DEMs, but were affected by the flattening of the valley floor. The linear errors in the valley floor also are evident in the aspect map. Interpretations of aspect have taken into account the flattened nature of the valley floor.

3.3.3 Soil and Vegetation Data

Detailed digital maps exist for both the soil and the vegetation covering most of the area visited by the archaeological survey. As well, a surficial geology digitized from the Wood Mountain 72G 1:250 000 scale map (1992 edition) was also available. The soil survey was done by the Saskatchewan Institute of Pedology at the University of Saskatchewan in May of 1991. The resulting map is one of hundreds of discretely defined areas or polygons, with an accompanying list of attributes. Detailed attributes of the soils were recorded, including soil type, slope, landform, soil texture, salinity, stoniness, soil texture, acidity, past erosion, and susceptibility to erosion. For the purposes of analysis, soil stoniness and erosion were the most important. The surficial geology map for the Park area was digitized from a 1:250 000 scale map, and consequently is less detailed than other maps of the Park. It classifies the Park into alluvial, colluvial, glacial, bedrock, and glaciofluvial landscapes.

The vegetation maps for the West and East Blocks were created by D.A. Westworths and Associates Ltd. of Calgary, Alberta. Mapping consisted of ground surveys with sample plots and was completed by April 1994. The vegetation data was mapped in terms of polygons with assigned attributes. These polygons are the same ones used in the soil survey. Recorded attributes include vegetation community, vegetation landscape units, and vegetation richness. The vegetation community attribute describes the dominant species in a given map unit. For example, a polygon with a vegetation community code of "RS" has a description which defines the main vegetation types in this area as a "Rose – Buckbrush vegetation type". Because the vegetation map is specific, fairly detailed analyses could be done on the association between vegetation types and site location.

3.3.4 Remote Sensing Data

After two years of this project had been completed, Grasslands National Park was able to make two sets of remote sensing data available for the purposes of this research. The first is a Landsat Thematic Mapper (TM) image, which is made of three images of standardized ranges of light wavelengths referred to as bands three, four, and five. This image was obtained, geo-corrected, and enhanced for the Park by the Saskatchewan Research Council (McTavish 1997). The image was created on May 10, 1995, so it reflects spring water levels and vegetation patterns. Stretches were applied to each of the bands as enhancements so the data that the Park received were not the original TM data. Nevertheless, it was possible to produce a colour composite of bands five, four and three using the program IDRISI v.4.1. This colour composite was useful in mapping water sources in the Park and for getting an understanding of the vegetation patterns present within the Park.

Bands three, four and five use red (band three) near infrared (band four) and mid-infrared (band five) portions of the spectrum (Lillesand and Kiefer 1994:469). Water absorbs energy at these wavelengths, particularly at near infrared wavelengths of the spectrum, making these bands useful for mapping water bodies (Lillesand and Kiefer 1994:19). It is possible that very wet soils or wet vegetation would have similar reflectance values to open water (Lillesand and Kiefer 1994:19). Wet soils in G.N.P. most likely would occur in association with sloughs which are included when mapping water sources.

To map water within the colour composite image of the West Block a supervised classification of the image was conducted using IDRISI's maximum likelihood classifier algorithm. Areas of alkali and non-alkali water were separated out during classification (Figure 3.2). To produce a map of non-alkali water sources, areas classified as non-alkali by IDRISI were used as well as the Frenchman River. In addition, some smaller water bodies which escaped classification were added in. The classification was checked so that no large water bodies were missed and no alkali water bodies were included. The resulting map is a combination of the major permanent water source in the form of the Frenchman River and non-alkali seasonal water sources. This classification was never field tested but the classification was straight forward so that the map is accurate enough to assess the general relationship between site locations and water sources.

The second remote sensing dataset is a SAR fine 5 beam, single look image of the West Block of the Park, created on April 2nd, 1997. The image is an extremely large file (over 525 megabytes) and was not geo-referenced or filtered to reduce speckling common to radar images. The specked nature of the image is in part a result of the image being a single look image. Digital Environmental Management of Saskatoon kindly allowed the use of their remote sensing lab so that the radar image could be geo-corrected and despeckled. Once the image had been processed an attempt was made to classify water bodies in the Park. This was unfortunately not possible for two reasons: the file size, even after a smaller study area had been cut out of the original, was too large to permit speedy processing and the image could not be despeckled sufficiently to permit a consistent range of classifiable values for water bodies.

Despite the fact that a software generated classification of water within the Park was not feasible, water bodies were mostly well defined within the radar image (Figure 3.3). Because

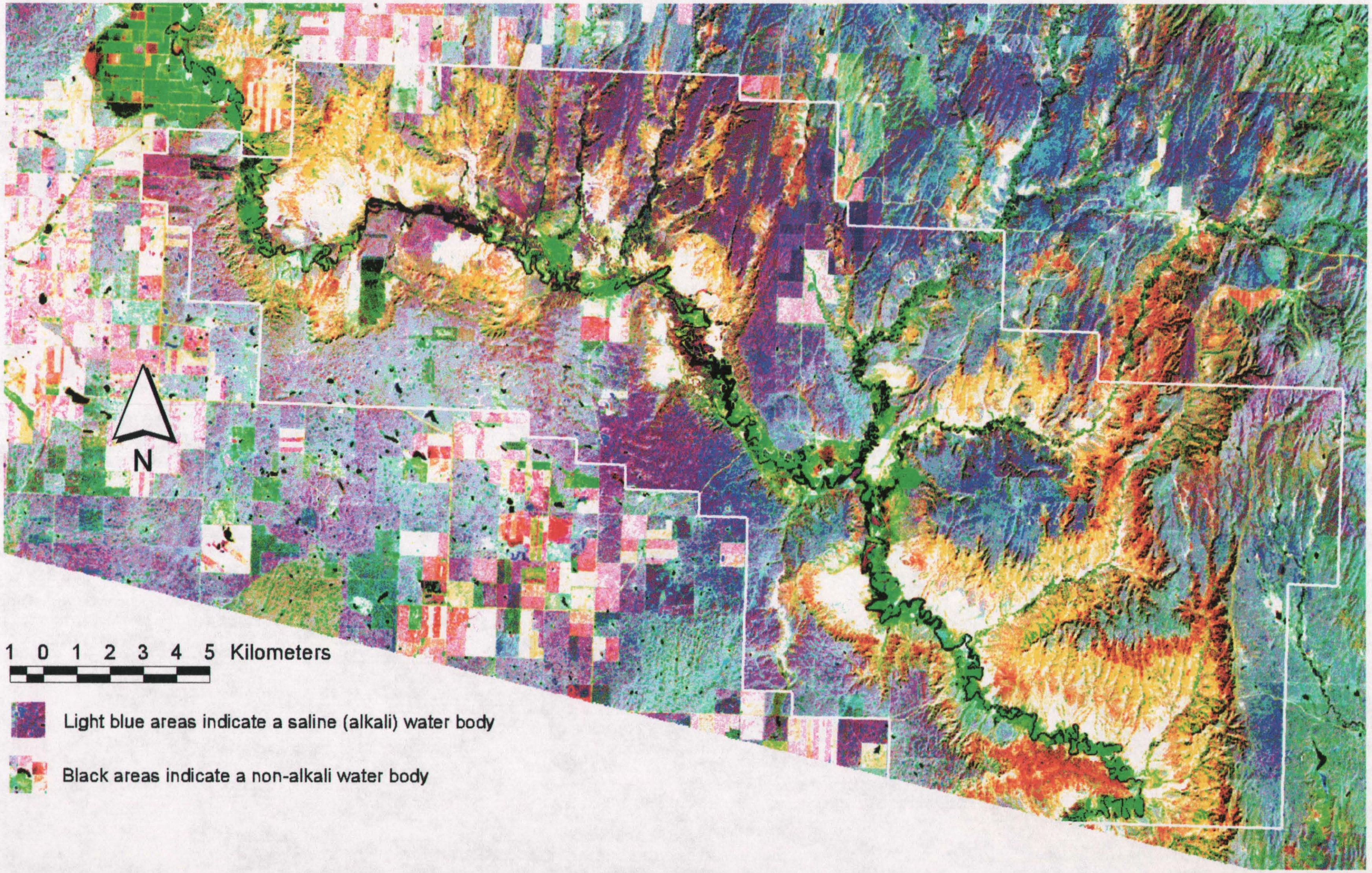

Figure 3.2 Landsat TM image of West Block Showing Alkali and Non-Alkali Water.

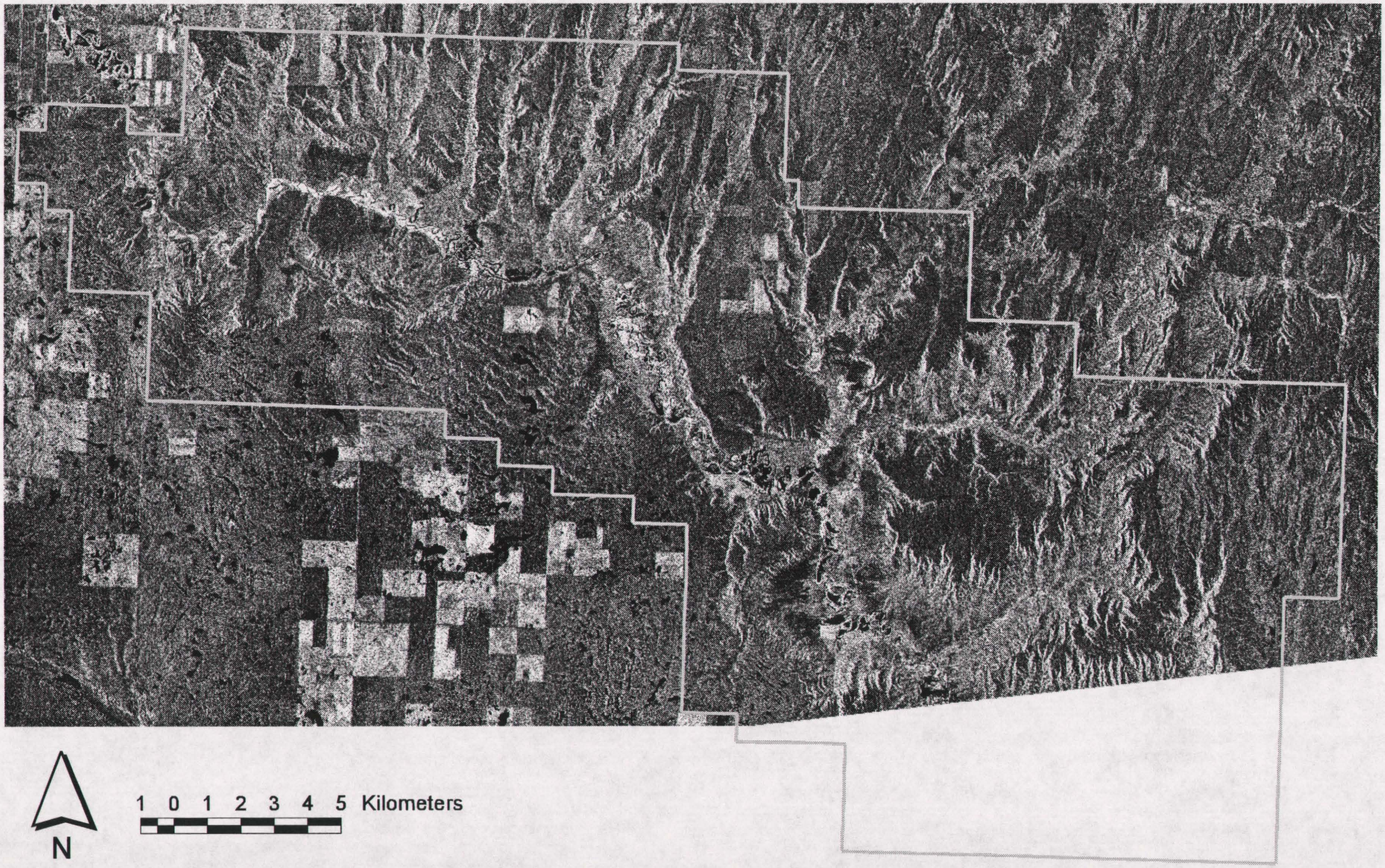

Figure 3.3 Radarsat Fine 5 Beam Single Look Image of the West Block, Taken on April 2nd 1997.

water, especially calm water, does not reflect the radar beam back to the radar satellite, surface water within the Park showed up as black spots within the radar image. In order to map these water bodies manually, the radar image was scaled down from a 3.125 meter resolution to a 9.645 meter resolution greatly reducing its size. The impact on the visibility of the water bodies was not great. This scaled down image was then used as a background for creating a detailed surface water map of the West Block using the program ArcView 3.0 to trace over visible water bodies and create water polygons. This was aided by switching between the radar image and the Landsat TM colour composite while mapping to try and insure that all features mapped actually represented water bodies and not something else. The aim of the detailed water map was to provide a higher resolution map of water resources within the Park than could be obtained from existing hydrology maps.

3.3.5 Other Digital Datasets

Two additional datasets are worth noting. The first is a map of bison drive lanes recorded during the archaeological survey. The West and East Blocks required two different methods of mapping for these features. The original bison drive segments were mapped onto air photo mosaics by the archaeologists who surveyed the Park. These air photos were not geo-corrected and were not easily transferred into a digital format. For the East Block the bison drive lane segments were mapped onto 1:50 000 topographic maps, which were scanned. The resulting image files were given geographic co-ordinates, and the bison drives were traced over using ArcView 3.0. For the West Block, the bison drives were digitized over the radar image which is similar to the air photo mosaics. This produced a more precise map of the bison drive lanes than could be created for the East Block.

3.3.6 Defining the Study Area

Another set of maps created for analysis were the maps defining the precise area to be considered for analysis. This set of maps was a combination of the areas looked at by the archaeological survey, as defined by quarter sections on the township grid, as well as a map of disturbed vegetation derived from the vegetation data. Essentially, all areas of undisturbed land visited by the archaeological survey were combined to produce a map defining the study area for both the East and West Blocks.

Sometimes the area covered by a map of a particular theme or variable did not correspond entirely with the study area map. For example, this was the case with the vegetation data inside the East Block. In these cases analysis was limited to areas where the map of the study area and the map of a variable overlapped. As a consequence of the changes in the area used for analysis sites which were included in one analysis might be excluded from another. This has meant that the number of sites used in an analysis reflects the area where the study area map and the map of the environmental variable under analysis correspond.

4.0 Methods of Analysis

This chapter reviews the methods used to analyze site and feature location as they relate to environmental or derived variables. Most of these were visual and statistical methods used to look for patterns in the data. As well, the process which was used to drive the research direction will be examined.

4.1 Visual Pattern Detection

Detecting patterns of site location by visually studying maps of site or feature locations distributed over different variables is an important step in gaining some sense of relationships that might be important. Through these initial observations it is possible to direct where statistical tests of apparent relationships might be appropriate. Figure (4.1) shows the distribution of sites with fire-cracked rock scatters and sites with stone rings over elevation classes for the west half of the West Block. Fire-cracked rock clearly is most often distributed in a valley bottom context, while tipi rings are in the uplands. With this apparent association, it is possible to use statistics to test whether the observed pattern could have been produced randomly. Statistical tests can serve to back up or call into question a pattern observed visually. Where visual detection can be important is in detecting patterns unique to a localized region. Since statistical tests look at distributions of sites as a whole, they do not reflect these localized patterns.

4.2 Statistical Pattern Analysis

Because visual pattern detection can only provide an impression of what patterns exist, statistical tests are useful for determining the probability that the observed distribution could have been produced randomly. For the purposes of this research, the single sample chi square test was

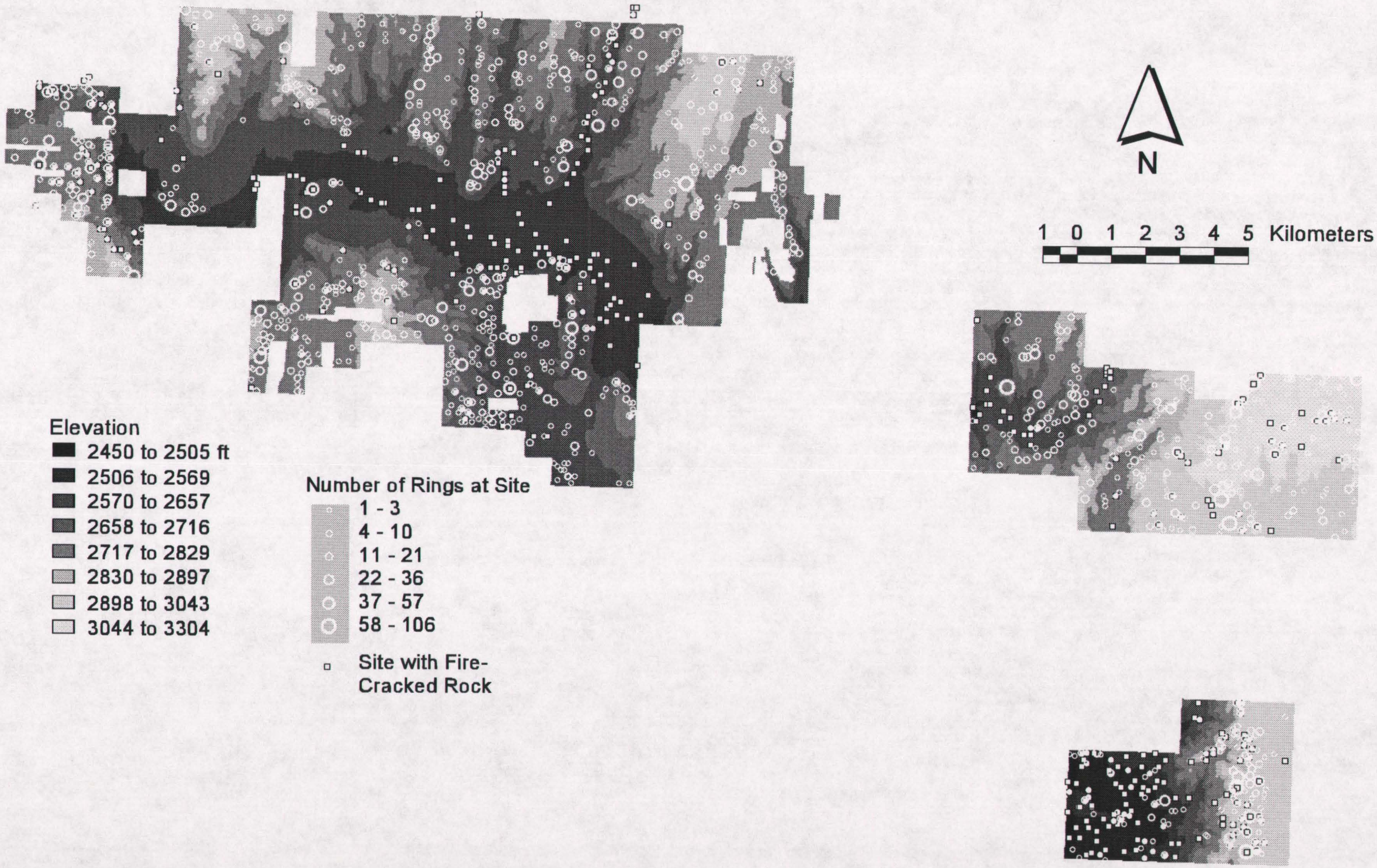

Figure 4.1 Distribution of Sites with FCR and Sites with Stone Rings over Elevation Classes, West Block.

used to test whether or not site or feature distributions could be attributed to a random pattern. The equation for the chi square test (Thomas 1986:265) is as follows:

$$x^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \qquad (4.1)$$

where x^2 is the symbol for chi square, O_i are the observed frequencies and E_i are the proportional expected frequencies for *k* classes.

The above equation produces a value for chi square, which can be compared against a table of critical values to determine whether the chi square value could have been produced from a purely random distribution, in other words, to test for statistical significance. Within statistics, testing a statistic for significance is generally put in the form of two hypotheses: a null hypothesis (H_0) and an alternative hypothesis (H_1) (Ebdon 1985:13). A statistic must disprove the null hypothesis, in other words the hypothesis which states that no relationship exists between variables, to be statistically valid. For the purposes of this research, the null and alternative hypotheses would be:

H_0: Archaeological sites or features are distributed randomly over a background variable.

H_1: Archaeological sites or features are distributed non-randomly over a background variable.

For the purposes of this research, a significance level of 0.05 was used, meaning that the probability of wrongly rejecting a null hypothesis would be five percent. This margin of error is not likely to have a large effect on the findings of this research and it is often used within the social sciences (Thomas 1986:216). For a chi square statistic to be statistically significant (and for the null hypothesisto be rejected), the chi square value must exceed a critical value, as determined from a table of critical values for chi square.

In certain instances, a greater understanding of the relationship between the type of site and the background variable was required. More specifically, this meant looking at the relationship of site size to the distribution of sites over a background variable. In these cases, a two sample chi square test was used to statistically test whether or not observed distributions could be attributed to a random distribution of different sized sites over a background variable.

Once a chi-square test was conducted and the result was statistically significant, the chi-square table was examined for trends in the data. Table 4.1 provides an example of one of the tables used in the analysis. In this case, the distribution of stone ring sites over different classes of elevation was examined.

Table 4.1 Example of Single Sample Chi-square Table, Distribution of Stone Rings over Classes of Elevation, West Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2450 to 2505	6.79	20	26.7	0.04	
2	2506 to 2569	31.89	32	125.6	69.75	-
3	2570 to 2657	58.44	149	230.2	28.64	-
4	2658 to 2716	35.06	155	138.1	2.07	+
5	2717 to 2829	65.37	314	257.5	12.40	+
6	2830 to 2897	24.52	132	96.6	12.97	+
7	2898 to 3043	32.43	183	127.8	23.84	+
8	3044 to 3304	12.55	67	49.4	6.27	+
Totals		267.05	1052	1051.9	155.98	

degrees of freedom: 7
sig. 0.05: 14.07

The chi-square value is higher than the 0.05 level of statistical significance, so the test is statistically valid. For the purposes of this chi-square test values greater than or equal to the arbitrary value of two are taken to show a significant departure from a random pattern. Positive or negative signs were placed beside chi-square values of two or greater to help clarify whether sites were negatively or positively associated with a particular class. Using the table formatted in this way, it is possible to describe the general relationship between site location and the variable being tested. In this case, it is clear that stone rings appear to have no particular relationship to the lowest elevations, while they are generally negatively associated with areas below 2656 ft. and positively associated with areas higher than that. Two sample chi square tests (Appendix B) were generally interpreted in a similar manner, where positive and negative associations were noted in an effort to define what the overall trend and relationship between two variables might be.

Ideally, analysis becomes a combination of both visual and statistical pattern recognition techniques. The two techniques support each other in that they can be used to check the biases or inadequacies of each other.

4.3 Assumptions About Site Types and Their Classification

The basic method used here is to compare the location of sites with maps of environmental variables. In many regional analyses using GIS, all sites are compared to the environment without reference to their possible function. This is often the result of a small sample of sites to begin with. Often this leads to very general statements about the relationship between settlement and the environment. This thesis divides sites into different categories by implied function in an attempt to expose some of the complexity of settlement patterns within southern Saskatchewan. As will be shown, certain site and feature types tend to exist in very different areas. When taken all together as generic sites, sites and features of different functions can have conflicting patterns of site location which tend to cancel each other out producing an impression that very little patterning is occurring at all. This might mean that sites with one feature type tend to lie in the valley while sites with another feature type tend to lie in the uplands, giving the impression that sites in general are distributed over all parts of the landscape. Because of the very large sample of sites for use in this analysis, sites have been broken down into stone ring, lithic scatter, fire-cracked rock, and hearth feature distributions. The classification of a site as one kind or another does not assume sites have exclusively one feature and many sites have multiple features.

The assumed functions of the site and feature types are as follows. Stone ring sites are well established as having a dwelling function. As a consequence, habitation and domestic activities are associated with these features. Lithic scatter features are the product of lithic material reduction, tool making, or tool sharpening. Fire-cracked rock is the result primarily of heating stones to boil water. On the Northern Plains, boiling water is often associated with rendering grease from animal bones. Generally, an association with the processing of a kill is made. Other functions can include the remains of a sweatlodege or rocks which made up a hearth. Hearths might have a number of functions, such as heating, cooking, roasting, smudging, or heating rocks to boil water. As we shall see, the many possible functions of hearths may prevent them from providing a clear pattern in terms of settlement. If more information on the type of hearth present were available in GIS format, it may have been that different types of hearths would have had different distributions. Cairns were not considered, because it was anticipated that they would have the same problem as discussed for hearths. Cairns are so numerous and have so many known and unknown functions that it would have been difficult to analyze them. A future analysis focusing specifically on cairns in Grasslands could easily fill a separate report.

Sites of a ceremonial nature provide an additional problem. It is considerably more difficult to anticipate what aspects of the environment would be relevant with reference to the locations of ceremonial sites. While elevation might be important, would distance from water sources be important? It can also be difficult to quantify in a map form characteristics which might be relevant to ceremonial sites. For example, how would one classify areas with an impressive view from digital topographic data? This requires a subjective assessment of a particular spot as it actually exists in the real world. Another problem is the classification of ceremonial sites. While medicine wheels have a fairly obvious ceremonial functions, the question remains are all elongated cairns ceremonial? Are there differences between large and small cairns? The best approach would be to start with sites whose ceremonial status is fairly certain.

The above points illustrate the requirement that any study of ceremonial sites in Grasslands would have to be fairly extensive. Consideration of local Native traditions regarding the nature of ceremonial sites in Grasslands would be important in such a study including consultation with knowledgeable Native people . Because this study cannot expect to examine patterns of general site location and the environment as well as give a due consideration of ceremonial sites, ceremonial sites will only be dealt with in a general manner, particularly as to how their locations are related to patterns of other types of sites.

4.4 Expanding Analysis from the Simple to the Complex

The approach used by this thesis has been one where questions arising out of the initial analysis were allowed to drive the direction of the research. The results of initial analyses created new questions which were addressed with a new set of analyses. Research can branch out in various directions. Ultimately the possibilities are endless and we are only limited by the limitations of our data and our ability to model processes. Figure 4.2 provides an example of

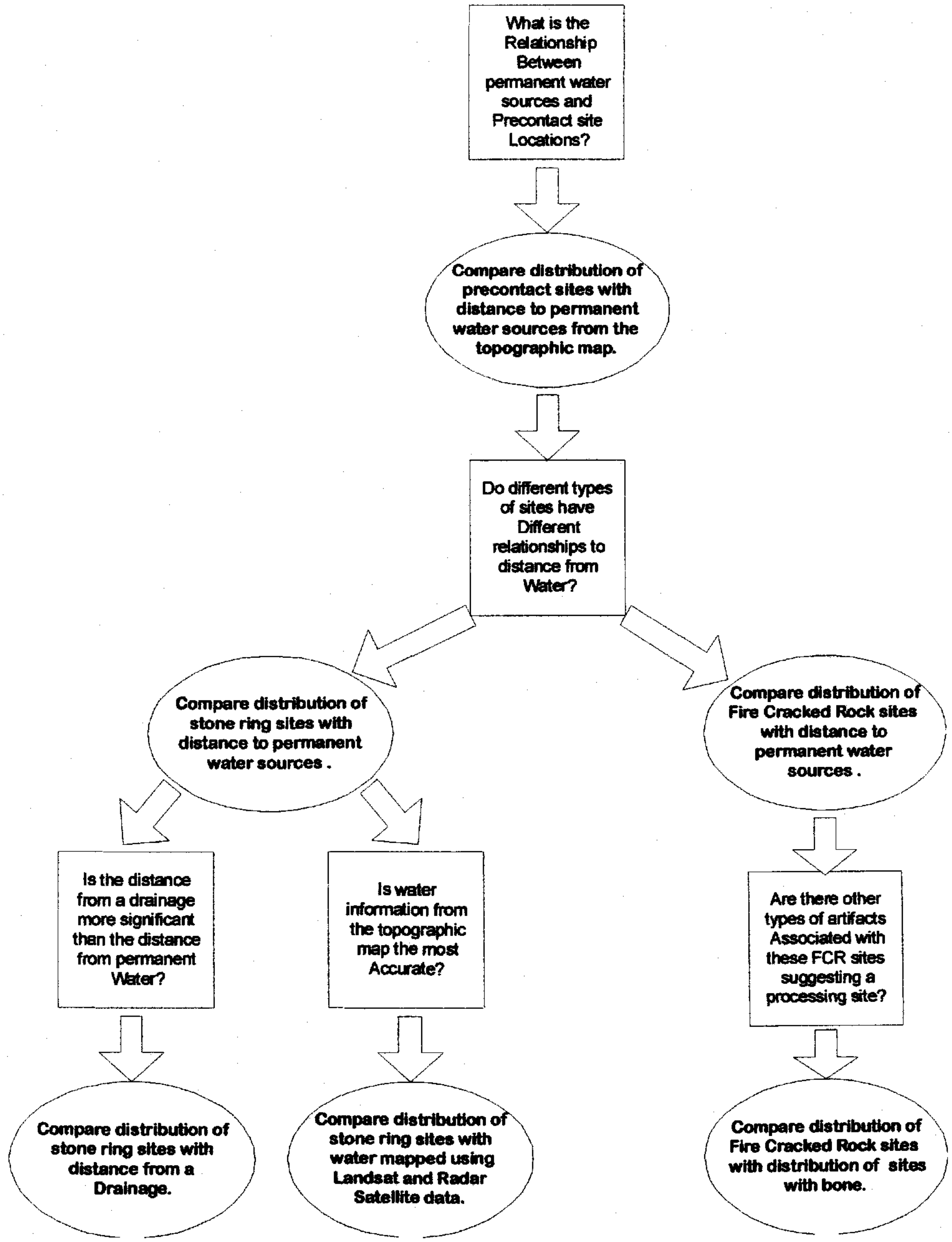

Figure 4.2 A Decision Tree Showing Expanding Complexity of Analysis.

expanding analysis. The advantage to using this type of approach is that initial analyses of a general focus can be made to develop into focused, detailed analyses. The analysis here will depart from simply reviewing obvious patterns within site locations and try to gain some understanding of the more complex aspects patterning within site locations.

5.0 Geological History and Patterns of Site Locations

Understanding the geological history of Grasslands National Park is fundamental to understanding the archaeological record as we observe it now. Geological processes have tended to obscure different periods of prehistory in the past depending on patterns of landscape change and the deposition of sediments (Butzer 1982:260-261). This section will seek to outline the geological forces at work which may have had an effect on the preservation, burial, or destruction of archaeological sites within the study area.

Of particular note are two terms used throughout this thesis. When sites or features are said to have a *positive* association with a variable, this refers to a state where there are more sites or features in a mapped zone than would be expected given a random distribution of sites over the study area. A *negative* associations refers to a state where there are fewer sites or features in a mapped zone than would be expected given a random distribution of sites over the study area. In other words the terms "negative" and "positive" are used in a statistical sense in this case.

5.1 Geological Processes Affecting Site Visibility

5.1.1 Deposition

For the Frenchman River Valley, and for stream valleys in general, deposition of sediments appears to be a major factor in the shaping of the landscape. A wood sample dated at ca. 10 000 radiocarbon years before present (rcybp) was recovered from deposits 37 to 13 m deep in the Frenchman valley, while two locales ca. 7300 rcybp yielded wood from sites 26 to 14 m deep (Christiansen and Sauer 1988:1704). Two locales with wood from ca. 3500 rcybp came from depths of 5 m. This would seem to suggest that in some places earlier sites would be subject to burial and not appear in the archaeological record, at least in the valley and coulees. When the density of archaeological sites for a surveyed portion of the West Block of Grasslands National Park is considered, it is clear that large areas of the Frenchman River Valley and nearby coulee bottoms have low site densities compared to the uplands. However, a fair representation of projectile points recovered from the Frenchman River Valley in the West Block are from periods after ca. 5000 rcybp (Figure 5.1). This suggests that the depositional forces within this period were not significant along the valley bottom. The depths at which particular dates were obtained were highly variable suggesting that the deposition which occurred within the Frenchman River Valley was not constant throughout all parts of the valley.

An examination of the surficial geology of the West Block helps to clarify the picture to some degree. When considering surficial geology of the study areas of colluvial deposits along the valley walls have few sites in comparison with other areas. The chi-square test comparing surficial geology and total precontact site location (Table A1 in Appendix A) indicates that fewer sites than would be expected from a random distribution occur within areas of colluvium and to a lesser extent the same is true for alluvial deposits. This suggests that slumping or deposition from erosion on the uplands is depositing sediment along the valley walls, likely covering many of the sites which may have existed there. Spring flooding of the valley bottom may have had an effect on site preservation with the potential to bury or erode sites. While this may have reduced the number of sites visible on the valley floor, it does appear that a large number of sites from various time periods have survived providing some indication of cultural site patterning.

Within the East Block, site distribution does not appear to have been affected by surficial geology (Table A2). No statistically significant result was obtained from the chi-square test comparing surficial geology and total precontact site location. This may be due to the fact that the map from which the surficial geology information is derived is at too small a scale (1:250 000) and thus missing the required detail. Another possibility is that the specific geology of the East Block has characteristically different processes of deposition than the West Block during the time it was inhabited by people.

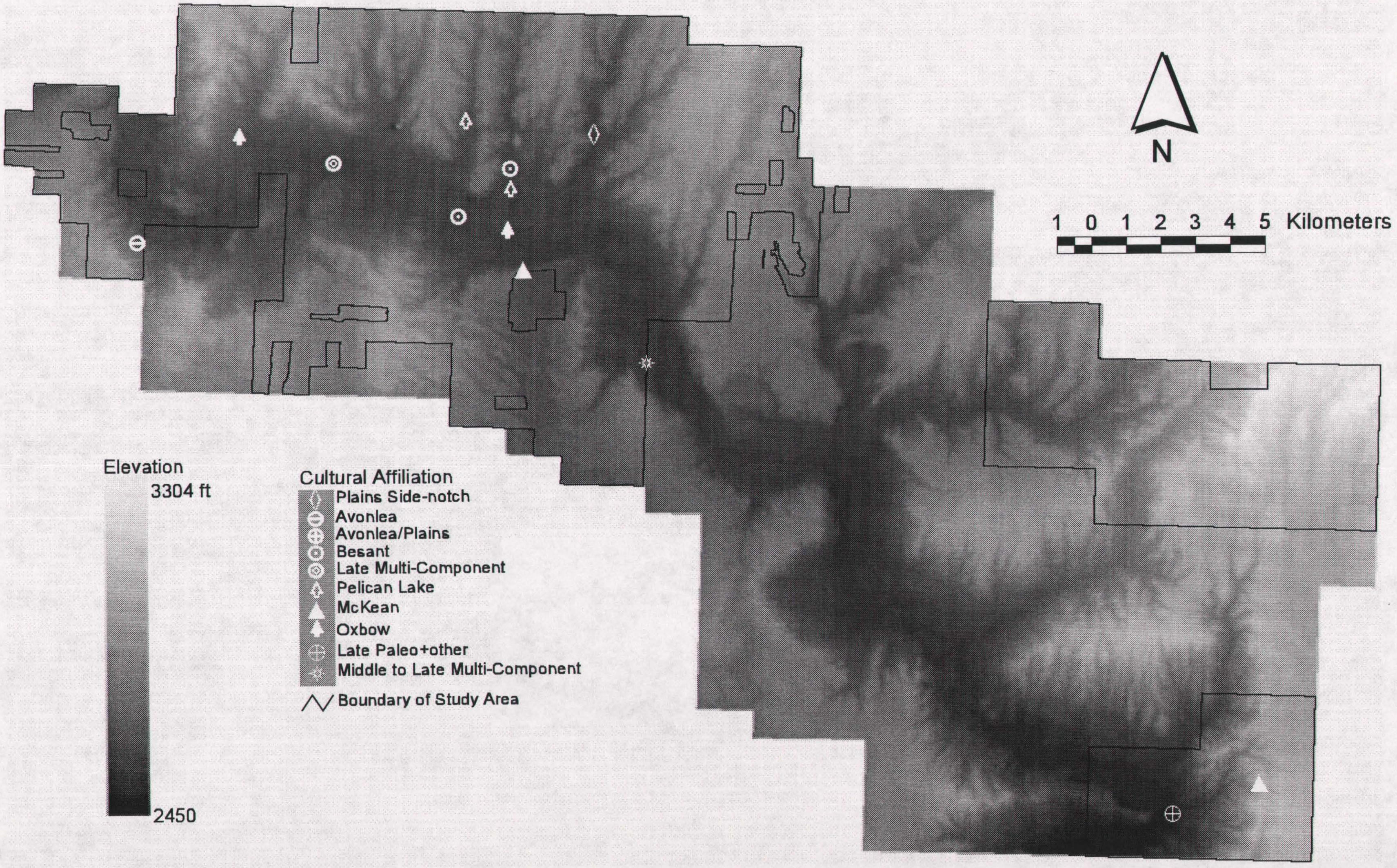

Figure 5.1 Distribution of Identifiable Projectile Points Over Digital Elevation Model, West Block.

Another major focus of sedimentation in the Park are depressions, especially those found in hummocky terrain. These areas would likely have been important as they often are a source of seasonal water in the spring and early summer (Vreeken 1994:532). The chronology of the deposition of sediments in these sites is still somewhat unclear. Sites which lie closest to the centre of these depressions would seem to have a greater chance of burial than sites towards the edges. As water receded inward as these depressions dried up over the summer people may have left evidence of their occupations closer and closer to the centre of the depression (Adams and Filopoulos 1995:13). This evidence would be covered by water and sediment the next spring. At the Ham geological site near Frontier in southwestern Saskatchewan (a depression), sedimentation was high some time before 6800 yr BP (Vreeken 1994:542) suggesting that sites by depressions created prior to this date would likely have suffered either from slopewash erosion or burial by sediments from slopewash. If sediments were somehow removed from these depressions, as Klassen (1994:1834) suggests as a possibility, the record is complicated further.

5.1.2 Erosion

The soil survey conducted within Grasslands National Park recorded information on soil erosion. Erosion was divided into six classes where class one was soils unaffected by erosion and class six was soils which were very severely eroded. Not all areas of the soil survey recorded erosion class, however, an area representative of the study area was classified and it was this partial map that was used to compare soil erosion and known site locations.

In the West Block, a chi-square test comparing erosion class and total precontact site location shows a distinct pattern (Table A2). Weakly eroded areas (class two) show a positive association with overall site location, while strongly to very severely eroded areas (classes four to six) were negatively associated with overall sites (Figure 5.2). This result is not unexpected and suggests that areas of weak soil erosion may in fact provide better visibility in terms of a site survey while more heavily eroded areas may have lost sites through site disturbance from erosional processes.

Figure 5.2 Distribution of Precontact Sites Over Erosion Classes, West Block.

The East Block once again departs from the expected pattern. The chi-square test comparing erosion class and total precontact site location shows no statistically significant relationship between soil erosion class and precontact site location (Table A3). Part of the problem may be that many sites tend to be located on the borders between soil erosion classes. This may have meant that sites which were on the edge of a moderately eroded region may have been inadvertently included in a more eroded class because the site location date is only accurate to within 50m of its actual location. The tendency of sites to sit on the borders of these classes probably relates to site relationships to vegetation and other cultural factors which will be examined later on.

5.1.3 Soil Stoniness

The number of stones present in given parts of a landscape have little bearing on the burial or erosion of archaeological sites, but they likely would have an effect on the presence or absence of archaeological features which are constructed out of stones. It can be generally assumed that stones would have to be present in some quantity before features constructed of stones might be present. Stone features in this case would include particularly stone rings, cairns, and rock alignments. To test how soil stoniness affects the presence or absence of stone features only stone rings were examined. In areas without stones to hold down the cover of a dwelling structure (most likely tipis in this case) it has been noted ethnographically that wood or bone stakes could have been used. This means that areas without stone rings could still have been dwelling locations. Thus the presence of sufficient stones to produce a stone ring could introduce bias into our understanding of where dwellings were located. This is less likely for features like cairns which are difficult to make out of anything but stone.

In the West Block, a chi-square test comparing soil stoniness and stone ring site locations provides us some idea of their relationship (Table A5). Areas where stones cover 0 to 0.1 percent of the surface are least likely to have tipi ring sites, particularly areas which were recorded by the soil survey as having no stones. This being said, areas where stones cover greater than 0.1 percent of the surface all are positively associated with stone rings. Interestingly, the strength of the association between soil stoniness and the presence of a stone ring site does not increase with increasing soil stoniness, once the level of stoniness where stones covering 0.1 percent of surface has been reached. This suggests that in areas where there are enough stones, the likelihood of finding a stone ring site is not a function of how stony the ground is.

In the East Block, we see a similar pattern using the chi-square test (Table A6). This time, the relationship between soil stoniness and ring site location is less straight forward. Strangely, we see a positive association between areas without stones and the presence of stone rings. This may have to do with the fact that areas with no stones are not large and scattered so that stones might have been transported into the edges of these areas. Otherwise, areas where stones cover less than three percent of the surface are negatively associated with stone ring sites, while areas where stones cover three percent of the surface or greater have no particular association or are positively associated with stone ring sites. In this case, increased soil stoniness appears to increase the probability of finding a stone ring site in a limited way. This being the case, less than 13 percent of stone ring sites in the East Block are on very stony ground (7 percent of the East Block study area), limiting the degree to which this increased soil stoniness introduces increased likelihood of finding stone rings sites.

Another consideration is whether soil stoniness influences the number of stone rings at a site. In the West Block, a chi-square test (Table B1) shows that a weak relationship exists. Areas where stones cover less than 0.1 percent of the surface tend to have ring sites of one or two rings only. Areas where stones cover greater than 0.1 percent of the surface tend to have more than one ring at a site except for very stony areas which generally do not have many sites with any number of stone rings. The fact that very stony areas do not have many ring sites of any size might be due to the fact that these very stony areas are often very eroded with little vegetation. People may have not chosen to locate dwellings in these inhospitable areas in the first place. The East Block does not provide us with a statistically significant chi-square test result.

5.2 Issues Surrounding Geology and Patterns of Site Location

In this chapter it has been shown that geological processes or characteristics have a definite bearing on where sites might be found within the study area. For the West Block, areas of colluvial deposits as well as areas classified as heavily eroded have fewer sites compared to other areas. The fact that sites in these areas may have been buried or eroded has to be taken into account when looking at cultural patterns of site location. It is not safe, however, to assume that purely geological considerations are the only possible factors at work in terms of the observed distribution of sites. Some of the eroded areas are dry stony slopes (Figure 5.3) which may have been unsuitable for any site producing activity. In other words, some areas where sites were likely removed from the visible record may never have had sites in the first place.

Figure 5.3 Eroded Vegetation on 70 Mile Butte, West Block.

Further complicating this issue is the fact that the present climate appears to be to a minor degree drier than of the past 2000 years. Areas which are now eroded may have contained more vegetation; possibly enough to make them more useful from a settlement perspective. Altogether, it seems likely that at least some highly eroded areas were avoided in the past and never had many sites to begin with.

The East Block is difficult to assess as surficial geology and mapped areas of erosion do not have detectable relationships to site location. It may be that while the West Block has larger and more continuous areas of a particular landscape type, the East Block is made up of smaller landscape divisions which defy generalization.

6.0 A Comparison of Patterns of Site Location and Topographic Factors

Comparing site locations with environmental variables has been a standard part of regional analysis using GIS. This type of comparison is often used to confirm ideas about where sites will tend to exist on a landscape and to find new relationships. This chapter will look at various aspects of topography and attempt to find reasons for observed patterns of site location. The chapter is organized into two basic parts. The first part will be a review of the results of the comparison of site and feature locations with selected topographic variables. Comparisons which did not produce statistically significant results will not be discussed, but will be included as tables in Appendix A. The second part of the chapter presents interpretations of the observed patterns of site and feature locations.

6.1 Definition of Variables and Archaeological Feature Types

6.1.1 Variables Used In The Analysis

A examination of patterns of site location as they relate to topographic variables is a standard part of regional analysis using GIS (Kvamme 1989). Variables were chosen on the basis of two criteria: they had to exist within the GIS dataset and they had to have some possible relationship to site location. A number of different variables were looked at in an effort to detect significant relationships between site locations and aspects of the physical environment. Variables considered are:

Elevation: absolute elevation, calculated as feet above sea level.

Slope: angle in degrees to which the slope of the landscape diverges from horizontal or flat.

Aspect: The direction in which the slope of the landscape is facing. This variable is measured in degrees, where zero is north, 90 degrees is east, 180 degrees is south and 270 degrees is west. Flat areas technically do not have an aspect and are given a separate class.

Distance From Permanent Water Sources: The shortest straight-line distance in metres from any permanent or year round water source. All locations within the study areas were assigned a distance from a permanent water source.

Distance From All Water Sources: The shortest straight-line distance from any water source, whether it is a year round or seasonal water source. All locations within the study areas were assigned a distance from all water sources.

Distance From Drainages: The shortest straight-line distance from any drainage indicated on the topographic map.

6.1.2 Feature Types and their Associated Functions

In addition to looking at the distribution of sites overall, the distribution of different feature types are considered. A number of features might occur at one site. If this were the case, the same site would be used to map the distribution of each feature type. In other words, the different distributions of feature types are not exclusive but make use of some of the same sites. For example, where stone ring features and a lithic scatter feature occur at the same site, the site will be included in the distribution maps of both stone ring features and lithic scatter features.

Archaeological features generally have specific functions related to them. The following describes the feature types used in the analysis and the functions which may be associated with them.

Stone Ring Features: For this analysis, stone rings refer to features considered to be the remains of stones placed to hold down the hide covers of tipis, in other words the remains of habitations. Sites with stone ring features are numerous in both the West and East Blocks, and range in size from 1 to 106 rings at a site, with an average of 6.8 rings per site. Where analysis was possible, the number of rings at a site was compared with the topographic variable in question.

Lithic Scatter Features: Lithic scatters in the Park are the result of either tool manufacture or tool resharpening (Adams and Filopoulos 1995:65). Lithic materials range from coarse to fine, but are not distinguished within the GIS database. For this study the distribution of lithic scatter feature locations were mapped as being present at a site. The total area in square metres of sites where lithic scatters are present was compared with topographic variables when this could add to the analysis.

Fire-Cracked Rock Features: Fire-cracked rock features are present at many of the sites in both the East and West Blocks of G.N.P. A number of activities can produce fire- cracked rock. Rocks surrounding a hearth may fracture due to heat producing fire-cracked rock while sweat lodges make use of heated stones which may also fracture due to heat. Large piles of fire-cracked rock were sometimes produced by grease extraction activities where broken bone was boiled in water filled pits lined with rawhide and heated with hot stones (Adams and Filopoulos 1995:66). For this study the distribution map of fire-cracked rock features was made up of sites where fire-cracked rock features were present.

Hearth Features: While less frequent than other feature types, a sufficient number of hearth features were recorded to allow for an analysis of their locations. Hearths had a number of possible uses, including cooking, heating, lighting, hide smoking, pottery firing, the heat treatment of lithics and heating stones to boil water for grease extraction. The distribution map of hearth features was made up of sites where hearth features are present.

6.2 Results of Comparisons of Site Location With Topographic Variable

6.2.1 Elevation

The West Block

Tables A7 through A11 show the results of a comparison of elevation classes with site distribution. Elevation classes were derived in a subjective manner. A histogram of elevation values within the study area was constructed. The peaks and low points in the histogram were observed. By grouping together all values within each peak in the frequencies of elevation values in the histogram, eight classes were created (Figure 6.1). The same process was used to create the elevation classes for the East Block. This method was chosen because it is thought that it will group elevation values in a way which is more meaningful than deriving classes from equal divisions of the range of elevation values. While elevation is difficult to quantify in some ways because the perception of elevation is relative to the landforms in an area, absolute elevation is still a useful measure of the positions of landforms within the Park.

In general, elevation appears to be an important factor affecting site location. Precontact sites overall are positively associated with the lowest elevation class, negatively associated with the next two lowest classes, and positively associated with classes of higher elevation. The fact that fewer sites than expected occur within classes two and three (2506 to 2657 ft.) appears to correspond with areas along the base of the valley and coulee walls. As was noted in chapter five, the base of the valley and coulees could be subject to deposition from slumping and upland

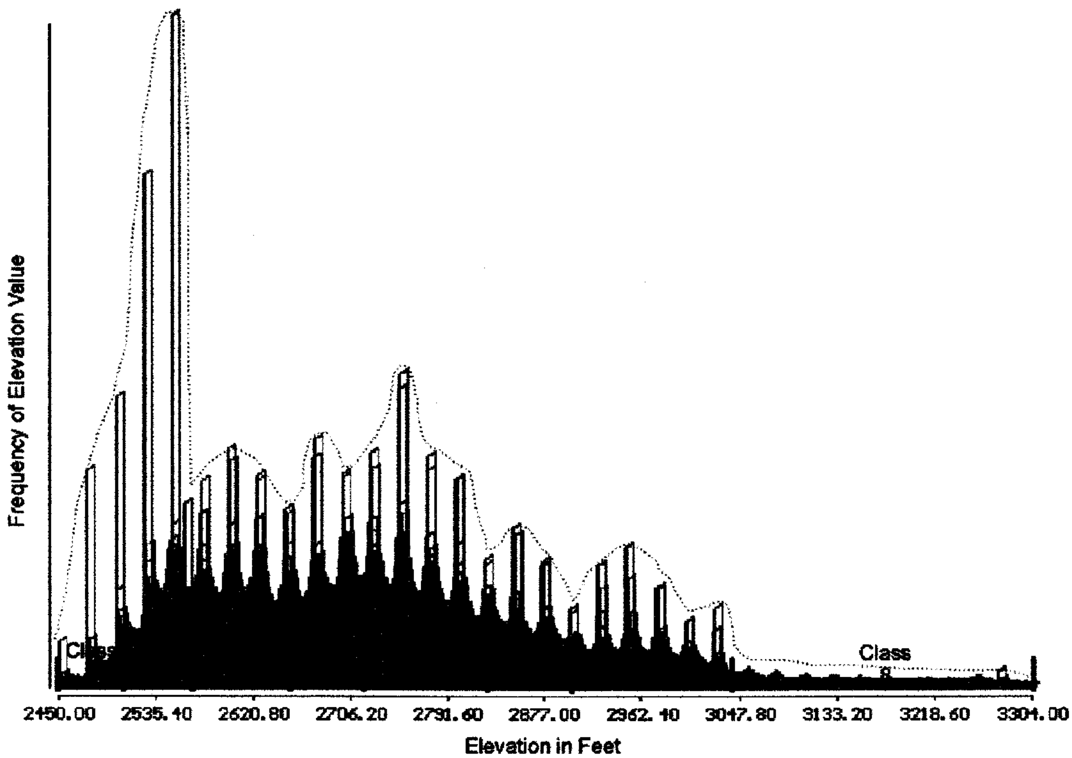

Figure 6.1 Frequency of Elevation Values, Grouped Into Classes.

erosion, which would effectively cover or destroy some sites in these areas.

Overall, site area appears to be related to elevation (Table B3). For the lowest two classes (2450 to 2569 ft.) no clear pattern is apparent. After this point, site area tends to increase with increasing elevation. This is likely a result of the large proportion of overall sites made up of sites with stone rings. As will be discussed, sites with stone ring features tend to be increasingly larger at higher elevations.

Sites with stone ring features show a definite association with higher elevations, particularly with classes five to seven or 2717 to 3043 feet (Figure 6.2). For this analysis, areas which are non-stony (classes 1 and 5) were removed from the study area. This eliminates the previously demonstrated bias against finding stone rings in non-stony areas. Even with non-stony areas removed, sites with stone rings are rarer in the valley and areas of low elevation. The chi-square test in Table B4 indicates that a fairly strong trend among stone rings sites is to become larger (have more rings) with increasing elevation. This pattern is independent of the number of stones in an area as stoniness is not correlated with elevation. In general, stone rings tend to be in upland areas and increase in size with elevation.

Sites with lithic scatter features tend to be found in the valley and are slightly less common at higher elevations (Figure 6.3). Conversely, Table B5 indicates that larger sites with lithic scatters tend to be at higher elevations, while smaller sites with lithic scatters tend to occur at lower elevations. Taken together, there is a pattern of more numerous but small sites with lithic scatters in the valley and less numerous but larger sites with lithic scatters in the uplands. These larger sites with lithic scatter features may be associated with the sites with stone rings which tend to be larger and more frequent as elevation increases.

Sites with fire-cracked rock features show a strong tendency to be located at lower elevations, or in the valley, while negatively associated with higher elevations (Figure 6.3). The valley bottom provides a ready water source (the Frenchman River) for boiling. In addition, the valley bottom would be the logical place for bison kill processing, as bison drives in the uplands terminate at the valley edges.

Figure 6.2 Distribution of Sites with Stone Rings over Elevation Classes, West Block.

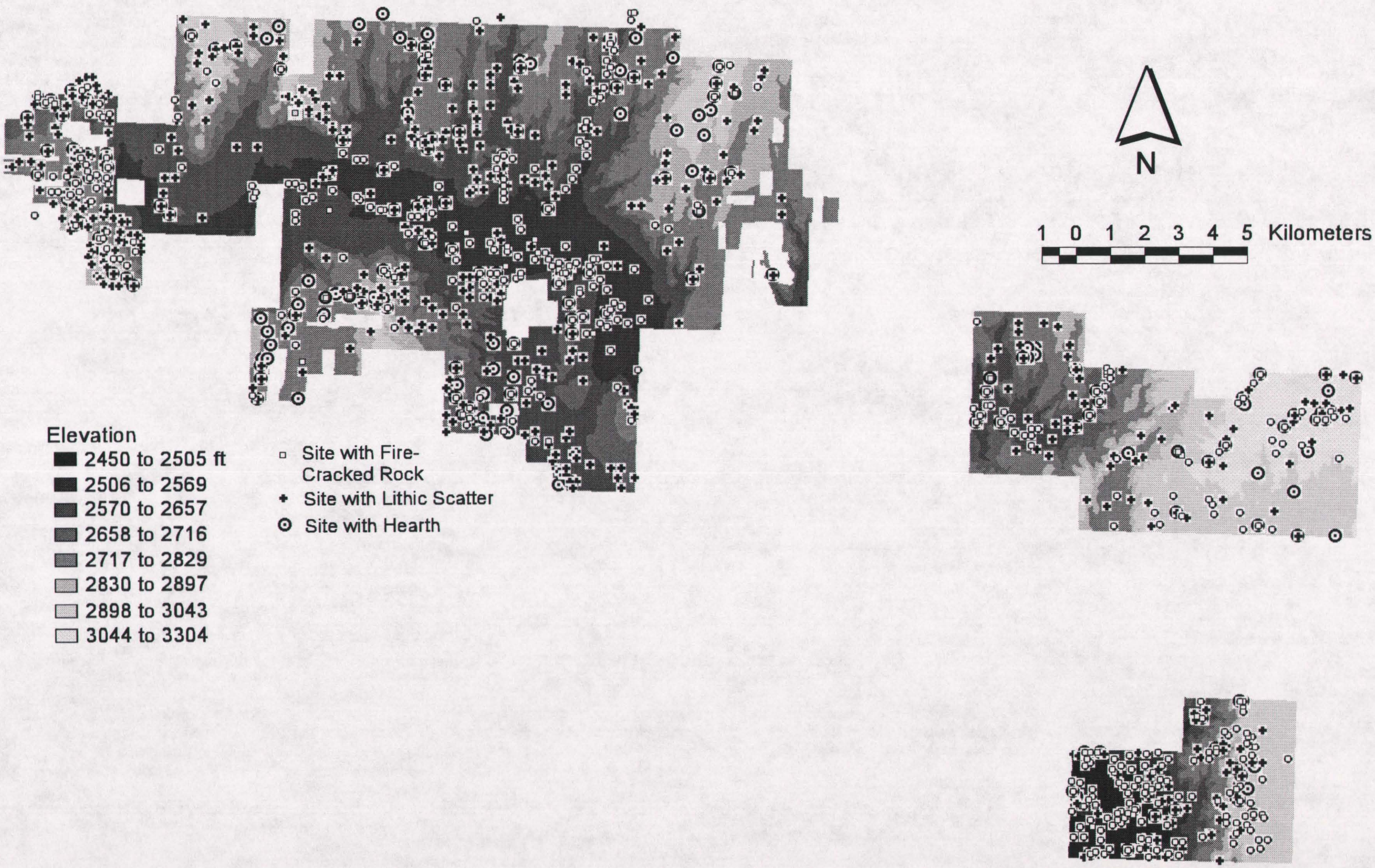

Figure 6.3 Distribution of Sites with Lithic Scatters, Sites with FCR and Sites with Hearths Over Elevation Classes, West Block.

Hearths do not show any strong associations, although they may be slightly more common at higher elevations.

The East Block

Tables A12 through A16 provide a description of the relationship between site location and elevation in the East Block. Unlike the West Block, the East Block is not dominated by any given topographic feature (i.e. a large valley). This may have resulted in a less distinct relationship between site location and elevation. Particularly, the East Block rises in elevation towards the north. This would mean that coulee or valley bottoms in the northern section of the block do not have the equivalent elevation in the southern section of the block.

Overall, there is a greater probability that sites will be located in areas of higher elevation (2964 to 3296 ft.) than areas of the lowest elevation (2539 to 2686 ft.). Sites with stone ring features show the same trend as overall sites, where stone rings are most likely found in at higher elevations while less likely to be found in lower valleys in the southern portion of the block (Figure 6.4). In this case, lower elevations are not particularly less stony than higher elevations which suggests that this trend is not the result of the availability of stones but presumably cultural factors.

Sites with lithic scatter features do not show a strong trend except that they are strongly associated with the highest elevation at the north end of the block. Sites with stone rings, sites with lithic scatters, and sites with fire-cracked rock are all positively associated with this area. This location is most closely associated with the Wood Mountain area, where there are standing groves of trees among rolling grassy hills as well as at least one spring. Trees of any size or number are not located anywhere else in the Park. Not surprisingly, this area seems to have been attractive because of these resources.

Sites with fire-cracked rock features are associated with the lowest elevation class (2539 to 2614 ft.) as well as the highest as previously mentioned (Figure 6.4). This area of low elevation corresponds with the place where Horse and Rock Creeks enter the block. These creeks comprise

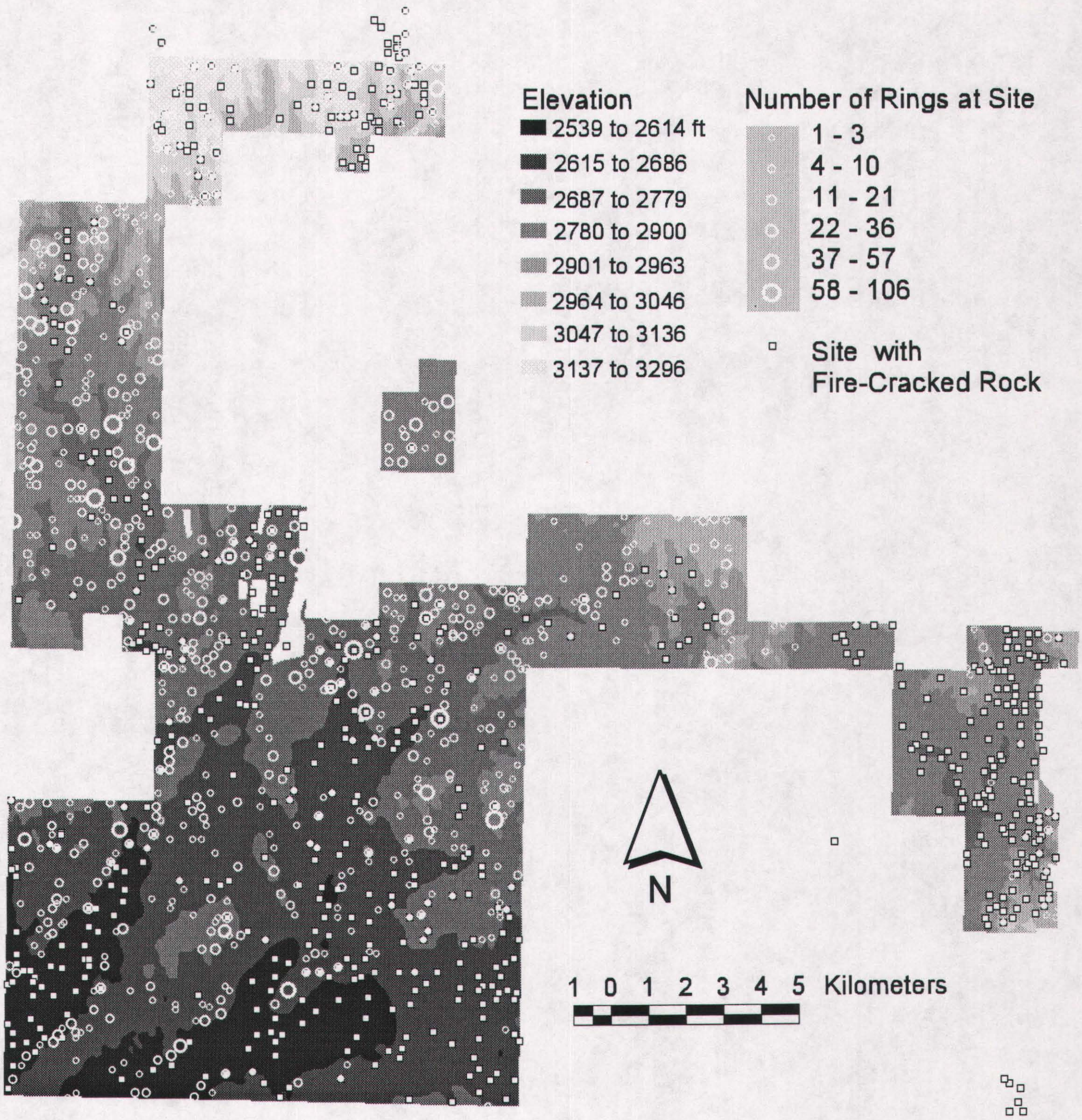

Figure 6.4 Distribution of Sites with Stone Rings and Sites with Fire-cracked Rock over Elevation Classes, East Block.

some of the major water sources for the East Block. As easily accessible water sources are important for boiling large amounts of water, the association of fire-cracked rock with this area makes sense.

6.2.2 Slope

The West Block

Slope classes had been created for the Park prior to this project, which resulted in reliable slope information. Slope classes range from one (no slope) to eight (over 40 degrees slope). The comparison of slope with site locations is shown in Tables A17 to A21. The meaning of slope classes is important for interpreting results of the following comparisons. Areas of a given slope class contain variability within them. Areas classified as steeply sloping may have small flat areas at the micro-landscape level. It is within these areas that sites with stone rings might be found, for example. This explains the location of some sites where they logically should not be (i.e. sites with stone rings on slopes greater than 40 degrees).

Sites overall are negatively associated with minor slopes (0.5 to 5 degrees or class two) while positively associated with slopes 10.1 to 20 degrees (Figure 6.5). The negative association with areas of minor slope may be related to the fact that many of these areas coincide with colluvial deposits which have previously been shown to be areas of potential site burial or destruction. Areas of 10.1 to 20 degrees slope (class four) often coincide with landscape edges. Landscape edges are known to be a preferred location for sites on the Plains.

Sites with stone ring features were analyzed with non-stony areas removed from the study area. In this case, flat areas and areas with 10.1 to 20 degrees slope (class four) are positively associated with stone rings, and areas 0.5 to 10 degrees slope (class two and three) as well as very sharp slopes (class seven) are negatively associated. As above, areas with class two and three slopes may have an association with colluvial deposits, while class four slopes are related to the landscape edge. Areas of generally very high slope may have had few flat areas where sites with stone rings could be placed.

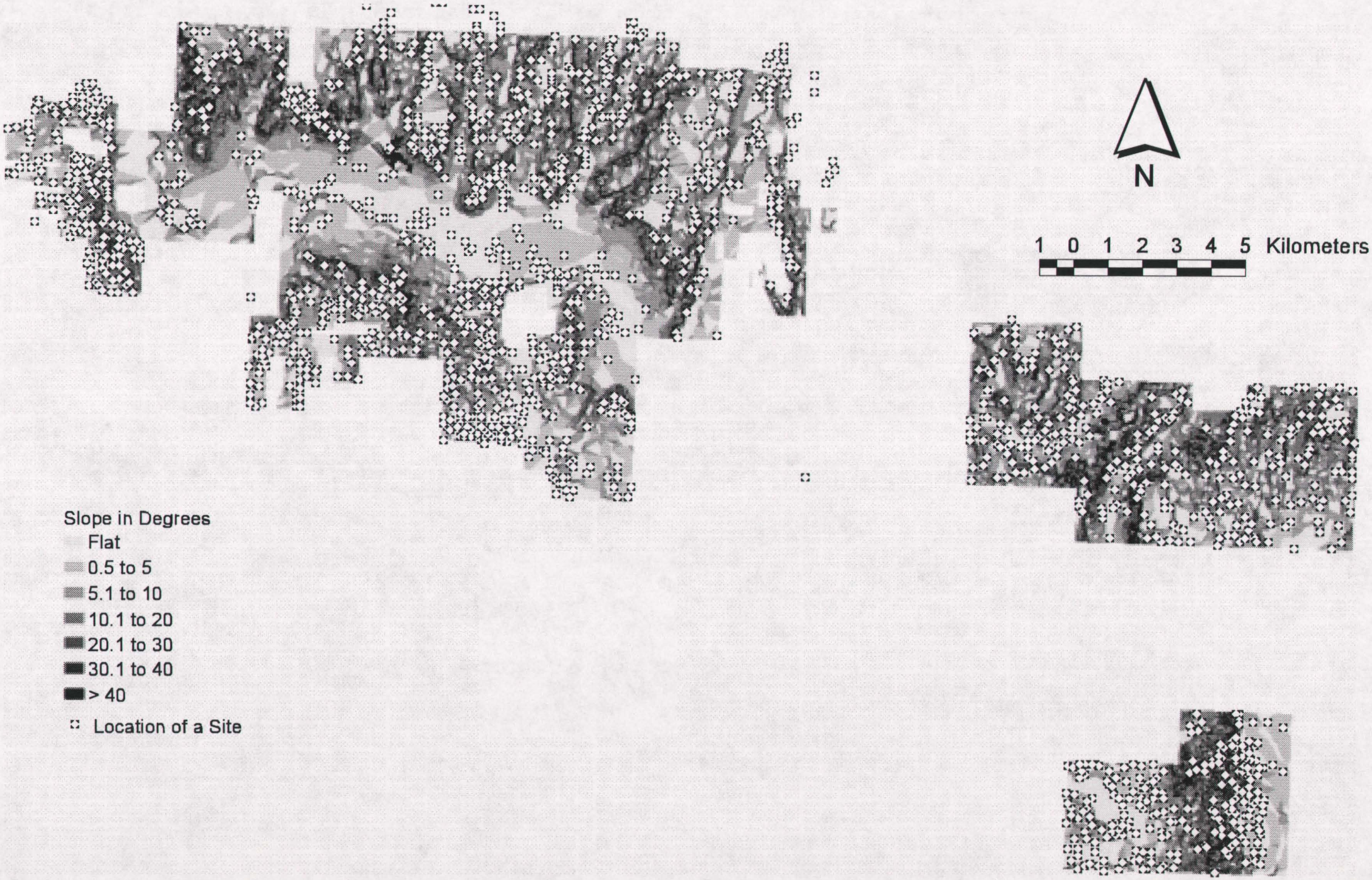

Figure 6.5 Distribution of Precontact Sites Over Slope Classes, West Block.

Sites with lithic scatter features are again negatively associated with class two slope (0.5 to 5 degrees), but show no other strong pattern. Sites with fire-cracked rock features are associated with flat slopes in the valley bottom while appearing less frequently where slopes are most acute. Generally, steep slopes would not be in the same location as water which may explain this pattern. Sites with hearth features are again less frequent in areas of class two slope while more common in areas of slightly more slope.

The East Block

Comparison of sites with slope in the East Block is contained in Tables A22 to A26. Sites overall are negatively associated with class 2 slopes (0.5 to 5 degrees) just as they were in the West Block (Figure 6.6). That these areas are locations where sediment deposition is occurring is not apparent. Also similar in pattern to the West block, overall sites are positively associated with class four slopes (10.1 to 20 degrees). This may again relate to areas along landscape edges. The steepest slopes are less likely to have sites than other areas.

Sites with stone rings tend not to be in areas of no slope or minor slope. We see a similar pattern to the comparison with sites overall, but associations are more pronounced. Sites with stone rings are strongly associated with class four slopes. The fact that stone rings would be associated with landscape edges is a common trend observed for both Blocks in G.N.P.

Slope is not strongly associated with either sites with lithic scatters or sites with fire-cracked rock. Sites with lithic scatters are positively associated with flat areas to some degree and negatively associated with class two slopes and the highest slope class (slopes greater than 40 degrees). Fire-cracked rock follows a similar pattern. Since both lithic reduction and boiling water using heated stones requires selecting stone and transporting it to some distance it makes sense that steep slopes were avoided.

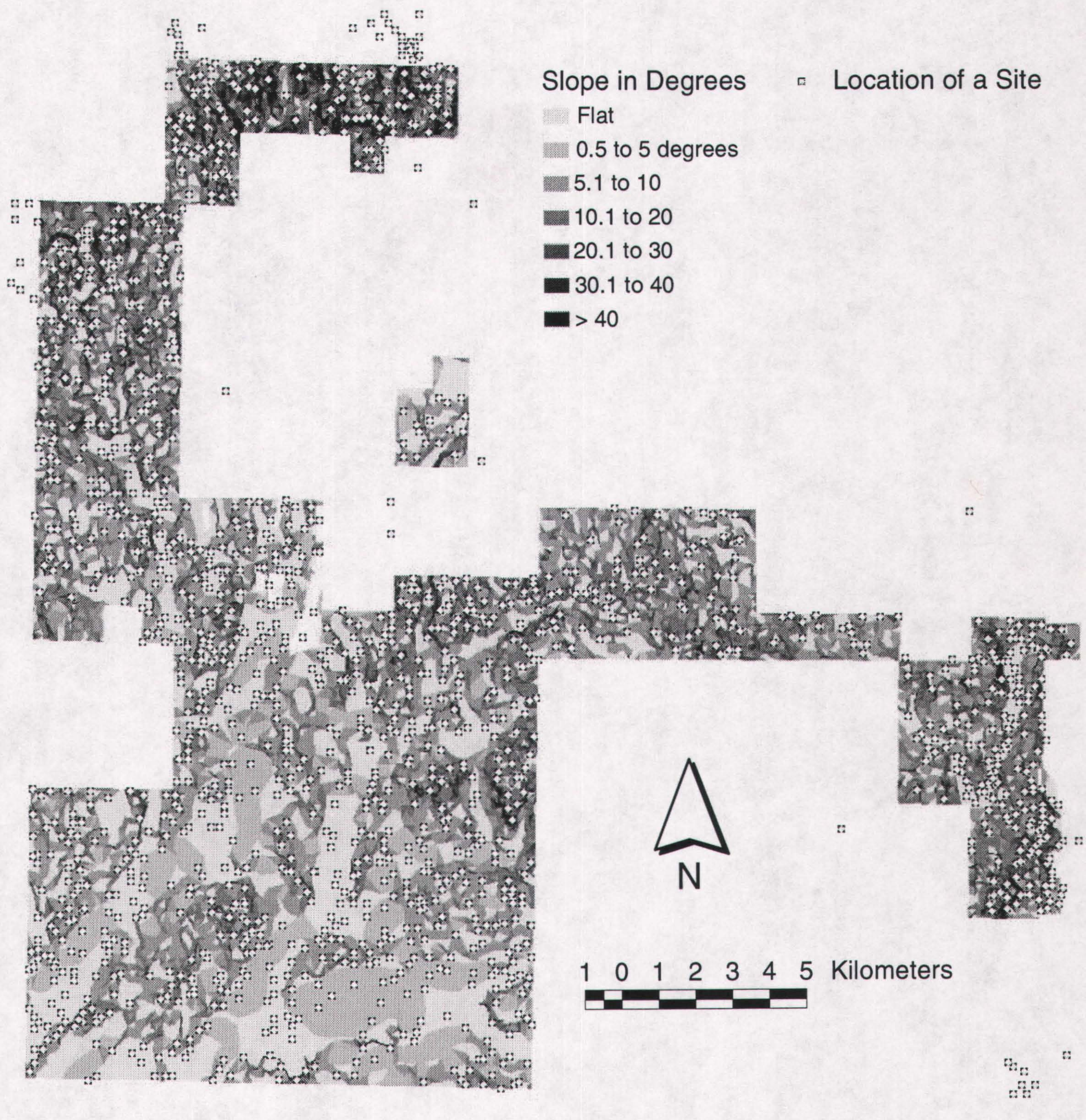

Figure 6.6 Distribution of Precontact Sites Over Slope Classes, East Block.

6.2.3 Aspect

The West Block

In this case, aspect was divided into nine different classes: eight cardinal points and flat areas. The comparison of aspect with site locations is given in Tables A27 to A31.

For sites overall, sites with stone rings, and to a lesser extent sites with lithic scatters, areas with a north, northeast, and easterly aspect were positively associated (Figure 6.7). Flat areas and areas with a southerly aspect were negatively associated. Flat areas are almost all located in the immediate flood plain of the Frenchman River. While they occupy only a small portion of the valley, they may be subject to erosion or deposition from spring flooding. The factors along with patches of thick grass may have reduced the visibility of surface sites. The intensity of the sun is likely to some degree responsible for the negative association with southern aspects. From the spring to the fall, areas with a southerly aspect would receive more direct sunlight than areas with a northerly aspect. As the Park is often very hot and dry from late spring to the fall, it may have been that south facing areas were uncomfortably hot. This greater heat may have caused south facing areas to become more heavily eroded than north facing areas. Vegetation is certainly sparser in areas with a southern aspect. While erosion may have impacted some sites, the thinner vegetation should increase site visibility. The apparently reduced number of sites found in areas with a southerly aspect appear to relate to an avoidance of these areas by groups in the past.

Areas of an easterly aspect likely relate to other factors. Weather records indicate that in the area around Val Marie, the wind blows most often from the west all year round (Atmospheric Environment Service 1982:56). An eastern aspect would provide some shelter for dwellings and cooking fires, etc. In the northern section of the main area of the West Block, landforms are mainly a series of coulees and upland areas which run north-south. Within these areas, it is readily observable that sites tend to be located on the east or lee side of these uplands (Figure 6.7). Further interpretations of site patterns related to aspect are considered under the interpretations section of the chapter.

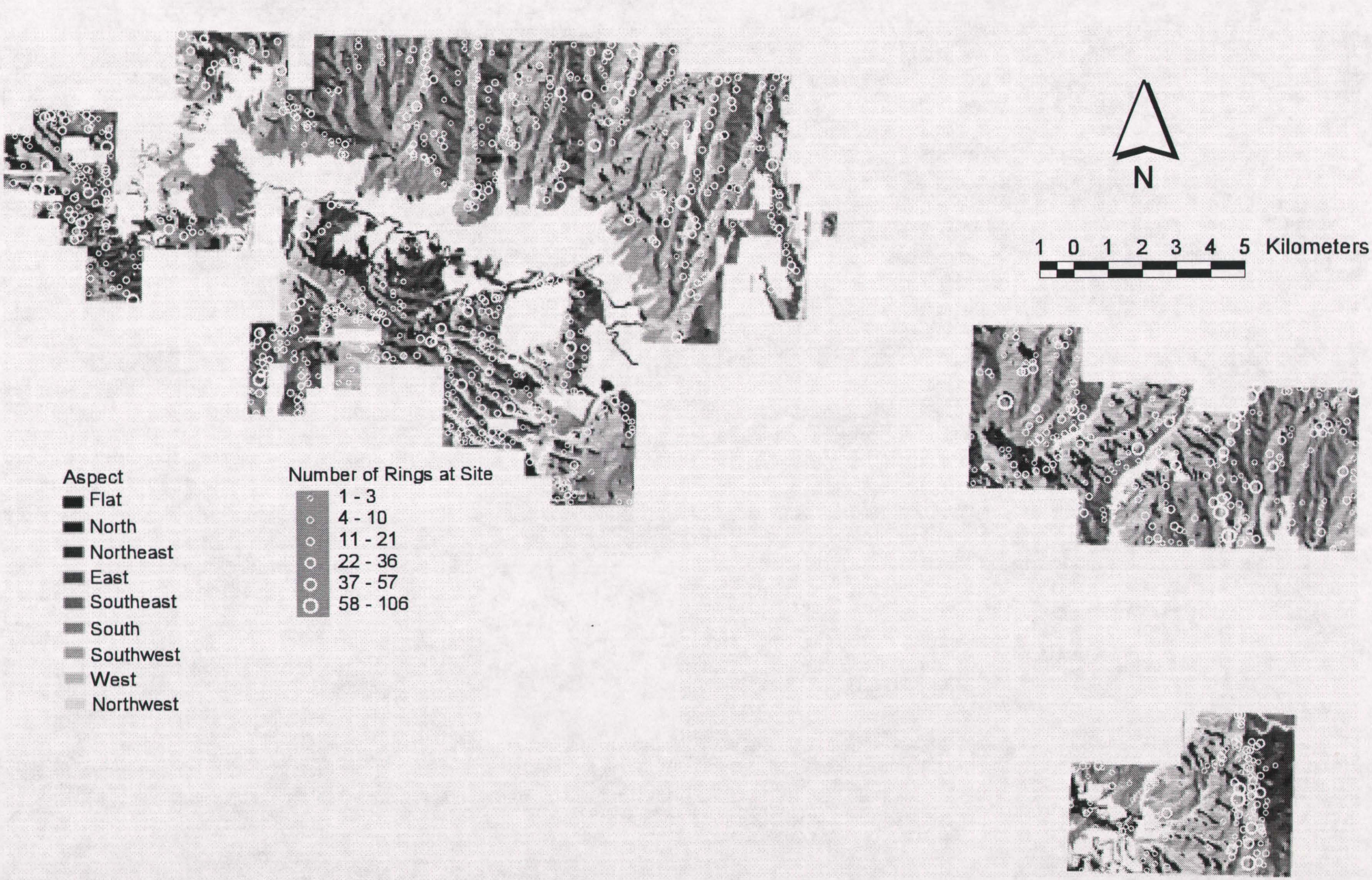

Figure 6.7 Distribution of Sites with Stone Rings Over Aspect Classes, West Block.

The East Block

The results of chi-square tests in the East Block are given in tables A32 to A36. Only the comparison of stone rings with aspect produced a statistically significant result. Areas with northeast and southeast aspects had a positive association with stone rings, while areas to the southwest had a negative association (Figure 6.8). Once again areas with a generally western aspect are again negatively associated with stone rings and areas of an eastern aspect are positively associated. This suggests that as in the West Block, prevailing wind direction may have had an affect on the location of sites.

6.2.4 Permanent Water Sources

Permanent water sources in the Park are variable to some degree. Water bodies which might have water throughout one summer might dry up as early as May in another. Certain springs which might have been active in one period might not be active in another. As well, the salinity of particular water bodies might render them undrinkable. Because the relationship between water sources and site location is not straight forward, site location has been compared to water sources in a number of different ways. Water sources defined by topographic maps (which are derivatives of air photos), defined by Landsat TM images, and a radar fine beam image are examined in terms of their abilities to represent the water realities of the Park. This first section looks at water sources identified as "permanent" via the topographic map data.

The way in which distance is considered can be approached from a number of different ways. Straight linear distance does not take into account the effort required to travel over different landforms. Steep slopes, for example, require more effort to travel over than flat areas, especially while carrying water. While this issue has been considered in other GIS regional analysis studies (Gaffney and Stancic 1991), an attempt to compensate for landform in the distance calculation will not be considered here. The main reason for this exclusion is that in order to accurately assess how landforms of an area affect the effort required to travel over a given distance, field trials are often necessary (Mark Gillings personal communication, 1997). Overall,

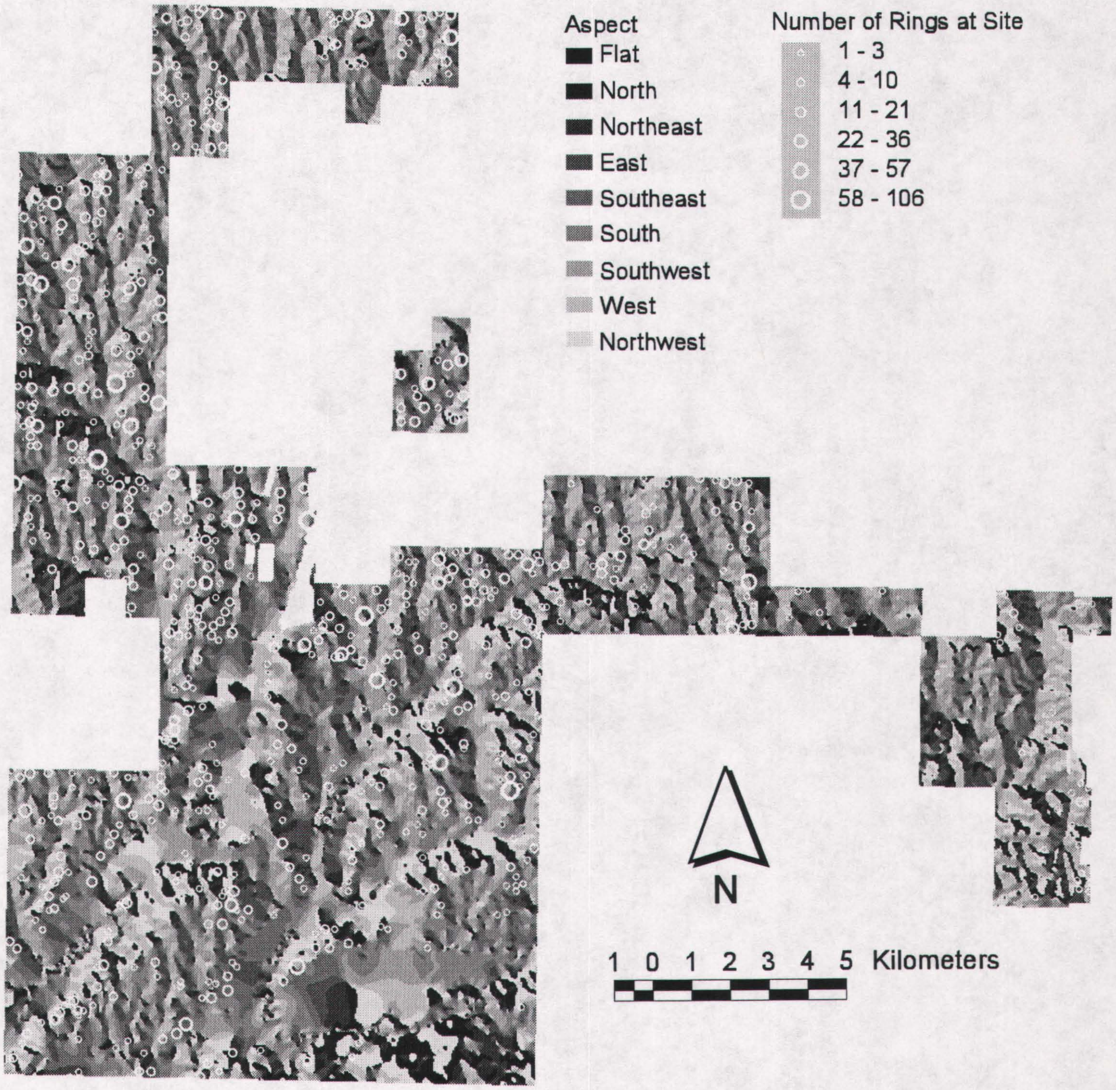

Figure 6.8 Distribution of Sites with Stone Rings Over Aspect Classes, East Block.

while a reliance on linear distance is not an accurate reflection of the effort required to travel over an area, the terrain lacks areas of extreme relief and travel over one region of the study area should not require much more effort than travel over another.

In an effort to make the dataset all inclusive, distance from water was calculated starting five kilometres outside the study area where possible. This insures that water sources just outside the study area are taken into account.

The West Block

Chi-square tests comparing site location and distance from permanent water are shown in Tables A37 to A42. In general the overall site distribution is weakly associated with distance from water. Areas 500 to 999 meters from permanent water are positively associated with overall sites while areas 1500 to 1999 meters are negatively associated. It is not clear why areas 1500 to 1999 meters from permanent water are negatively associated with overall sites while areas further away from permanent water show no particular association.

In this case, an analysis of stone ring locations changes significantly when the bias created by non-stony areas is removed from the study area. Table A38 provides the chi-square test prior to the removal of non-stony areas from the study area, and Table A39 is the test after removal. When the non-stony areas are removed, the results of the chi-square test become more in line with what one might expect. Sites with stone rings have a positive association with areas closest to permanent water (within 1000 meters), while areas further from water (1500 to 2500 meters) are negatively associated (Figure 6.9). Areas still further from water appear to have no particular relationship to sites with stone rings. Overall, the chi-square values are not very high, so permanent water sources do not appear as significant for stone ring locations as one might expect considering that water is an essential requirement for drinking and many domestic activities.

Sites with lithic scatter features and sites with fire-cracked rock show a similar pattern in relation to permanent water sources. Both are strongly associated with areas 0 to 499 meters from a permanent water source, particularly fire-cracked rock (Figure 6.10). Areas further away

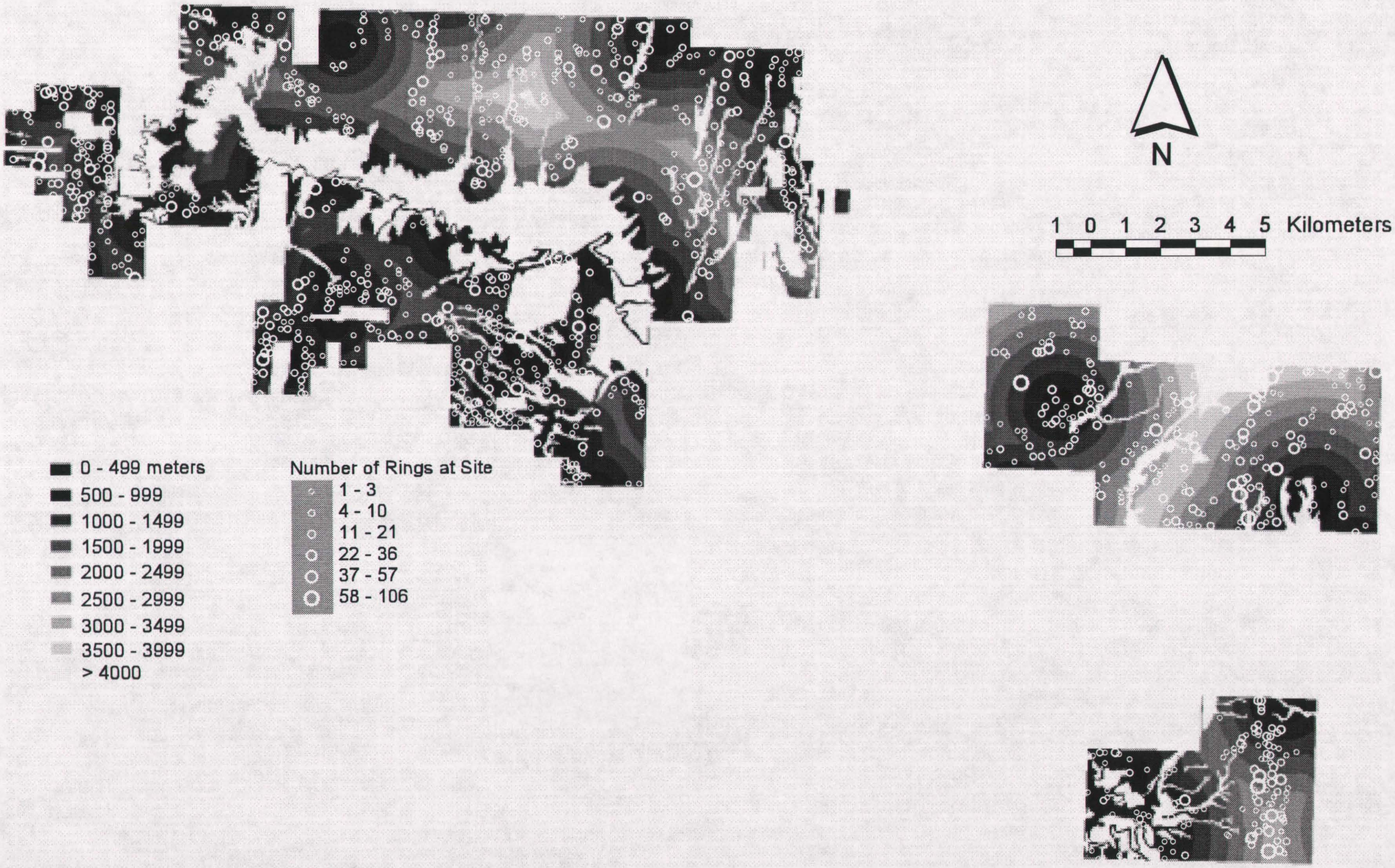

Figure 6.9 Distribution of Sites with Stone Rings Over Distance from Permanent Water Classes, West Block.

Figure 6.10 Distribution of Sites with FCR and Sites with Lithic Scatters Over Distance from Permanent Water Classes, West Block.

from a permanent water source are generally negatively associated with these features, but areas furthest away from water do not necessarily have the highest chi-square values. It makes sense that sites with fire-cracked rock are associated with water, as their main purpose was to boil water. It is less clear why lithic scatter sites are associated with water. It may be in fact that sites with lithic scatters are associated with or are the same as sites with fire-cracked rock.

The East Block

Results of chi-square tests for the East Block are given in Tables A43 to A47. Sites with stone ring features produce a result which is an exact opposite of what might be expected. Areas closest to a permanent water source are negatively associated with stone rings, while areas furthest away are positively associated (Figure 6.11). In this case, bias introduced by non-stony areas is not a factor like in the West Block. A possible explanation could be that permanent water sources away from the valleys and coulee bottoms are not adequately mapped. Indeed, a central issue when considering the association between water sources and site locations has been the mapping of water in terms of its significance to people in the past. For this analysis permanent water refers essentially to Rock Creek. There may be other water sources in the present or past (for example springs) which may have been significant permanent water sources in other areas of the Park. The other option is that this is a cultural pattern and the notion that habitation sites must be close to permanent water is not valid.

Sites with lithic scatters and sites with fire-cracked rock show a similar pattern in relationship to permanent water sources. Both feature types are positively associated with areas 0 to 499 meters from a permanent water source while areas further away in general have no particular association or are negatively associated (Figure 6.12).

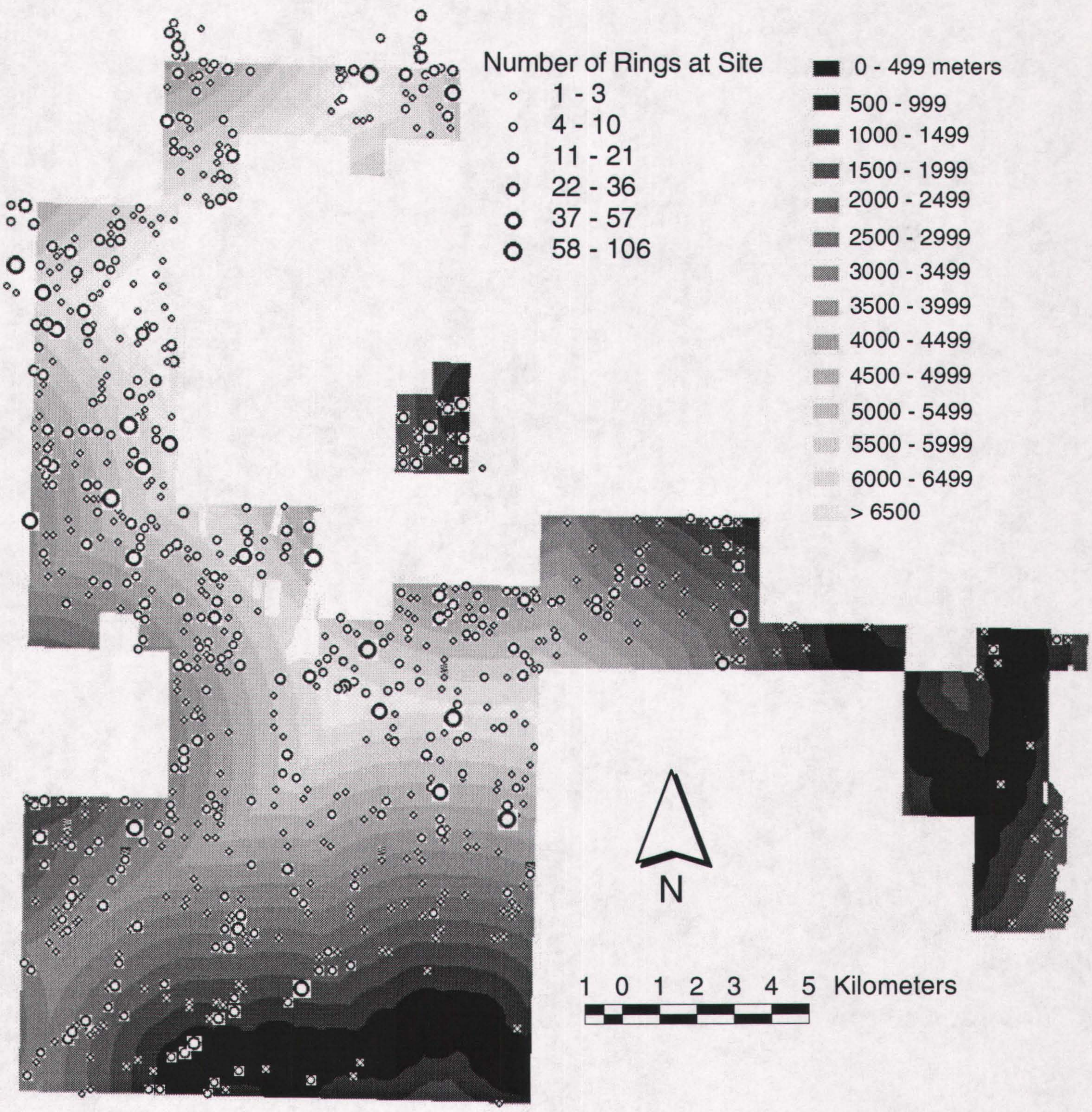

Figure 6.11 Distribution of Sites with Stone Rings Over Distance From Permanent Water Classes, East Block.

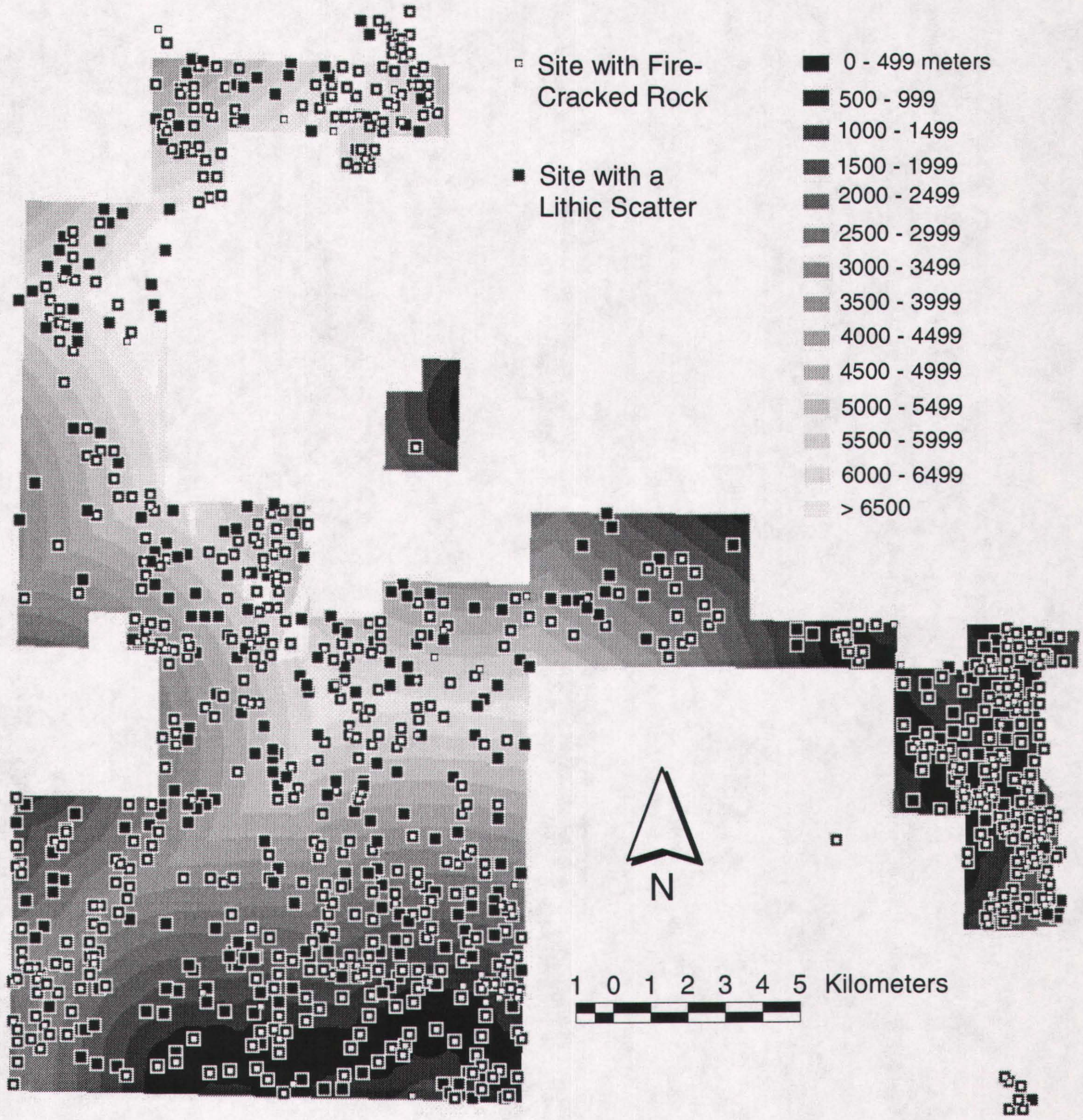

Figure 6.12 Distribution of Sites with FCR and Sites with Lithic Scatters Over Distance from Permanent Water Classes, East Block.

6.2.5 All Potential Water Sources

The West Block

In this analysis, site locations were compared with distance from all possible water sources mapped on the topographic map. The results of chi-square tests are given in Tables A48 to A52.

In the West Block, only tests of distributions of sites with lithic scatters and sites with fire-cracked rock produced statistically significant chi-square values. The pattern was similar to but less pronounced than the comparison of sites and feature locations with permanent water sources. Areas closest to water (0 to 499 meters) were positively associated while areas slightly further away were negatively associated (Figure 6.13). As permanent water sources were included along with all seasonal water sources, the statistically significant chi-square results may be a result of the relationship between sites with lithic scatters, sites with fire-cracked rock and permanent water sources.

The East Block

Within the East Block, only sites with fire-cracked rock features produced a statistically significant chi-square test result. Areas close to all water sources (0 to 499 meters) were positively associated with fire-cracked rock, areas 500 to 999 meters were negatively associated, and areas 2000 to 2499 meters were positively associated (Figure 6.14). The results are not straight forward but do suggest a relationship between sites with fire-cracked rock features and seasonal water sources.

6.2.6 Mapping water using Landsat Thematic Mapper Imagery

Given that a reliable water supply is essential for the maintenance of human and animal life, the analysis of the relationship between site location and water sources has not been as close as one might expect. A possible reason for this might be that water mapped by the topographic map is not a good representation of water sources which people used in the past. The topographic map represents all possible water sources without making a distinction as to the quality of the

Figure 6.13 Distribution of Sites with FCR and Sites with Lithic Scatters Over Classes of Distance from All Water Sources, West Block.

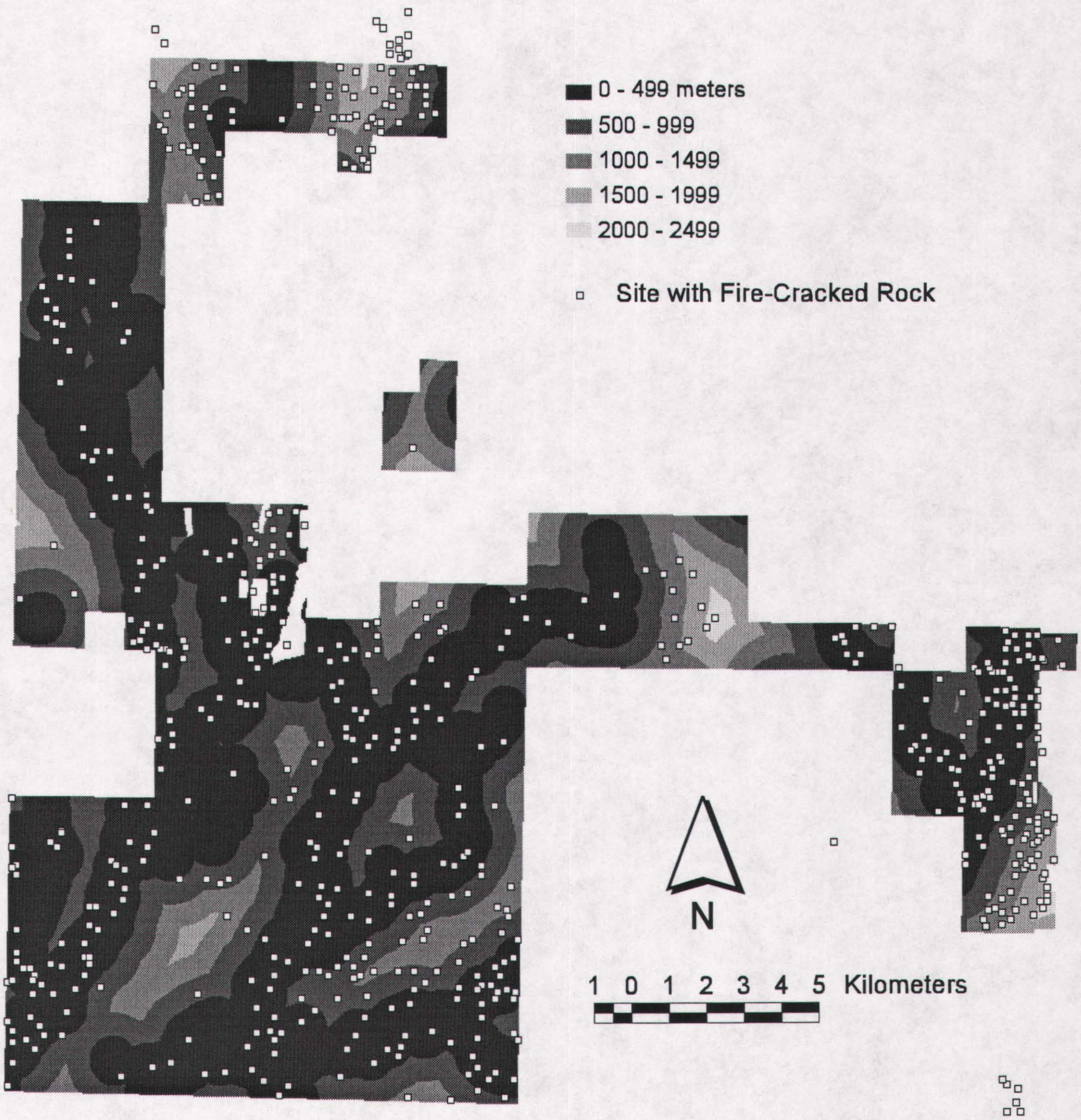

Figure 6.14 Distribution of Sites With Fire-cracked Rock Over Classes of Distance from All Water Sources, East Block.

water source or how long a water source might exist after the runoff in the spring. The use of Landsat Thematic Mapper (TM) imagery is an attempt to address some of these problems.

The map resulting from the classification of water bodies from the Landsat TM image shows substantial non-alkali surface water (sloughs or small lakes) as well as the Frenchman River (because it is a known year-round water source). While it was possible to map water in the West Block using the Landsat TM image, the East Block was not easily classifiable. The results will focus on the West Block as an example of how Landsat TM data can be used for mapping surface water quality on the Plains.

The West Block

Tables A58 to A60 present the results of chi-square tests. In this analysis, only sites overall, sites with stone rings, and sites with fire-cracked rock were compared to Landsat TM classified water. Sites overall did not produce a statistically significant chi-square result.

Stone rings were positively associated with areas 500 to 1000 meters from a classified water source while there were generally fewer stone rings than expected in areas further away from a water source. While a statistically significant relationship exists, permanent water sources identified on the topographic map show a stronger relationship with sites with stone rings.

Sites with fire-cracked rock features were strongly associated with areas 0 to 499 meters from a classified water source and generally negatively associated with areas further from a source (Figure 6.15). This test provides the strongest association between fire-cracked rock and a water source. This suggests that seasonal as well as permanent water sources were used for boiling water during the occupation of the Park area.

6.2.7 Mapping Water Using Radar Imagery

Radar imagery is useful for mapping water sources because water tends to show up very distinctly in a radar image. When radar waves emitted by a satellite hit water they are scattered and do not return to the satellite. The result is that these water bodies appear as distinctive black areas within a radar image.

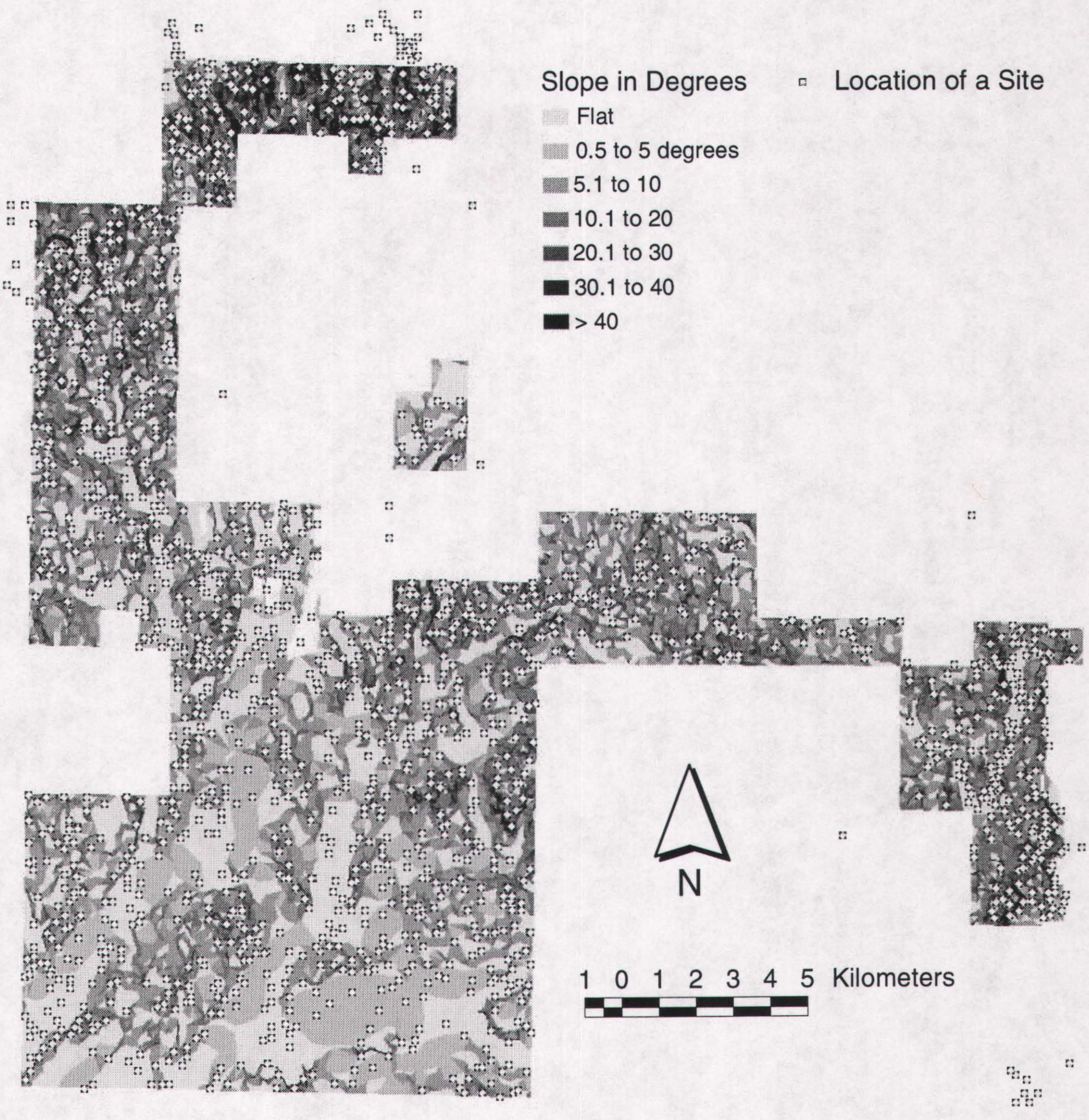

Figure 6.6 Distribution of Precontact Sites Over Slope Classes, East Block.

The intent of mapping water bodies using a radar image was to try and improve on the accuracy of the Landsat TM image which only has a resolution of 30 meters, as well to try to distinguish very ephemeral water sources from more substantial ones. Mapping surface water in this way produced a very detailed map of springtime surface water sources within the Park. As only part of the West Block was covered by the image, only the West Block, minus the southeastern section, is analysed.

The West Block

Tables A61 to A62 provide the results of chi-square tests. For this analysis only stone ring and sites with fire-cracked rock were looked at.

Sites with stone ring features were positively associated with areas 0 to 499 meters from radar mapped water sources while negatively associated with areas 1000 to 1500 meters from a water source (Figure 6.16). The fact that this comparison produces a statistically significant result is interesting. Water sources mapped via radar would appear at least superficially to be similar to all water sources from the topographic map and to some degree water sources mapped by Landsat TM. This comparison is different, however, because comparisons of stone rings and topographic map data and Landsat TM data failed to produce a statistically significant result. Mapping water via radar imagery appears to have identified some seasonal water sources which were significant to the location of sites with stone rings, unlike other mapping techniques.

Sites with fire-cracked rock features were positively associated with mapped water sources while the number of sites with fire-cracked rock further away from the water sources were generally less than would be expected randomly. The result does not show as strong a relationship as sites with fire-cracked rock compared with water sources mapped using the Landsat TM image. It appears that water mapped from radar imagery does not reflect the water sources which were most significant in terms of the location of sites with fire-cracked rock as accurately as other methods of mapping water.

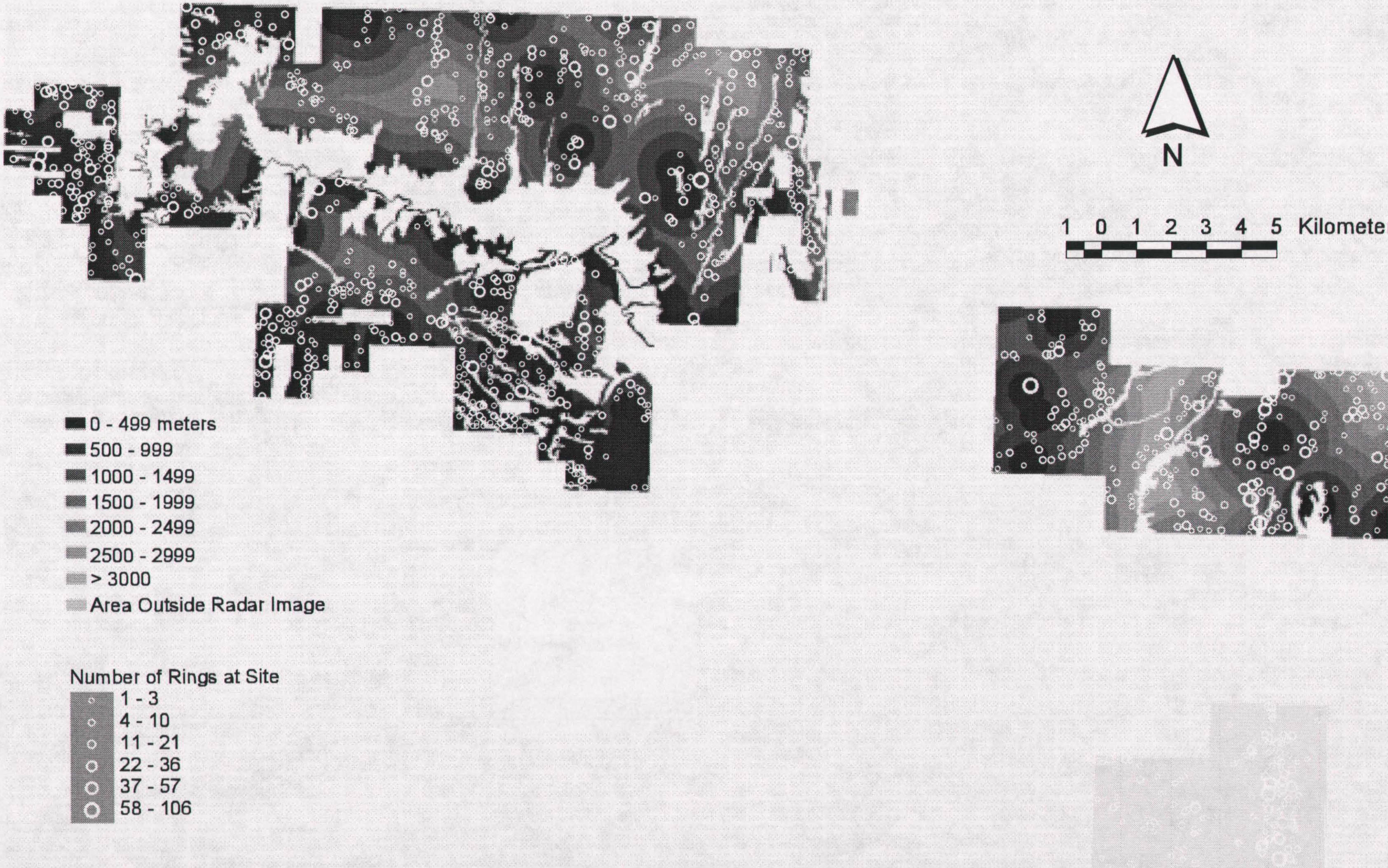

Figure 6.16 Distribution of Sites with Stone Rings Over Classes of Distance from Radar Image Mapped Water Sources.

6.2.8 Distance from a Drainage

A short analysis comparing site location with the distance from a drainage was conducted to explore this variable as a possibly significant factor in site location. The distance from a drainage may give some sense of the relationship between site location and the bottom and edges of drainages.

Because the distance from any given drainage was not very great, most of the study area would normally be covered by the first distance class (0 to 499 meters) when distance is measured in 500 meter intervals. To provide less skewed analysis, distance classes were adjusted so that they would produce classes of approximately the same area. Thus the first class is only areas 0 to 29 meters from a drainage, the second is 30 to 59 meters, and so on. The result is that it is possible to look at distance from drainages at a fairly fine scale.

The West Block

Sites overall were compared with distance from any drainage and the results are provided in Table A63. Sites are not likely to occur within 60 meters of a drainage, particularly within 30 meters. Areas 60 to 217 meters from a drainage are positively associated with sites as are areas greater than 732 meters from a drainage (Figure 6.17). It seems likely that areas closer than 30 meters to a drainage might be subject to erosion by that drainage, or may be associated with steep slopes. Overall, distance from a drainage is one of the most significant variables considered when looking at overall site distribution. The fact that archaeological surveyors focused on landscape edges during the survey may partially explain the strong association between the distance from a drainage and overall site locations.

The East Block

The results of the chi-square test comparing sites overall and distance from drainage are given in Table A64. The pattern is similar to the one observed for the West Block, but is less pronounced. Areas 0 to 29 meters from a drainage are negatively associated with sites, while

Figure 6.17 Distribution of Precontact Sites Over Classes of Distance from Drainages, West Block.

areas 60 to 127 meters and 309 to 751 meters from a drainage are positively associated with sites (Figure 6.18). It appears to be the case that areas just back from a drainage represent landscape edges which have been noted to have been of importance in terms of site location.

6.3 Interpreting Results

The results so far have provided a sense of which variables are associated with certain features and which are not. This section will suggest reasons for the patterns observed within the data. Results will be considered by feature type as opposed to individual variables. This approach will enable a consideration of how variables are related in terms of site location decisions.

6.3.1 Overall Site Location

Many of the patterns observed for sites overall are related to underlying location patterns of different feature types. As we have seen sites with different feature types may have very different patterns over the landscape. As will be discussed, sites with fire-cracked rock and sites with stone rings tend not to occur in the same places. As a consequence the patterns seen in sites overall tend to reflect the strongest trends of the underlying feature types. While this is often the case, some factors have a bearing on the general distribution of all sites .

Elevation has a strong bearing on site location in general. In some ways, elevation reflects landform. We see positive associations with the bottoms of large drainages as reflected in low elevations and positive associations with higher elevations which reflect upland areas of relief. If landforms could be classified in a consistent way sites would likely show strong associations with particular landforms. An issue in classifying landforms is the fact that classifications based on geological principles do not necessarily reflect the settlement realities of past peoples. Landforms have to be viewed in terms of how they would fit into subsistence and settlement requirements of precontact Plains groups.

In the East Block all site types are associated with areas of highest elevation class. This pattern does not appear to be entirely related to elevation, rather it relates to the environment characterized by the highest elevation class. This area is the part of the Park that overlaps with

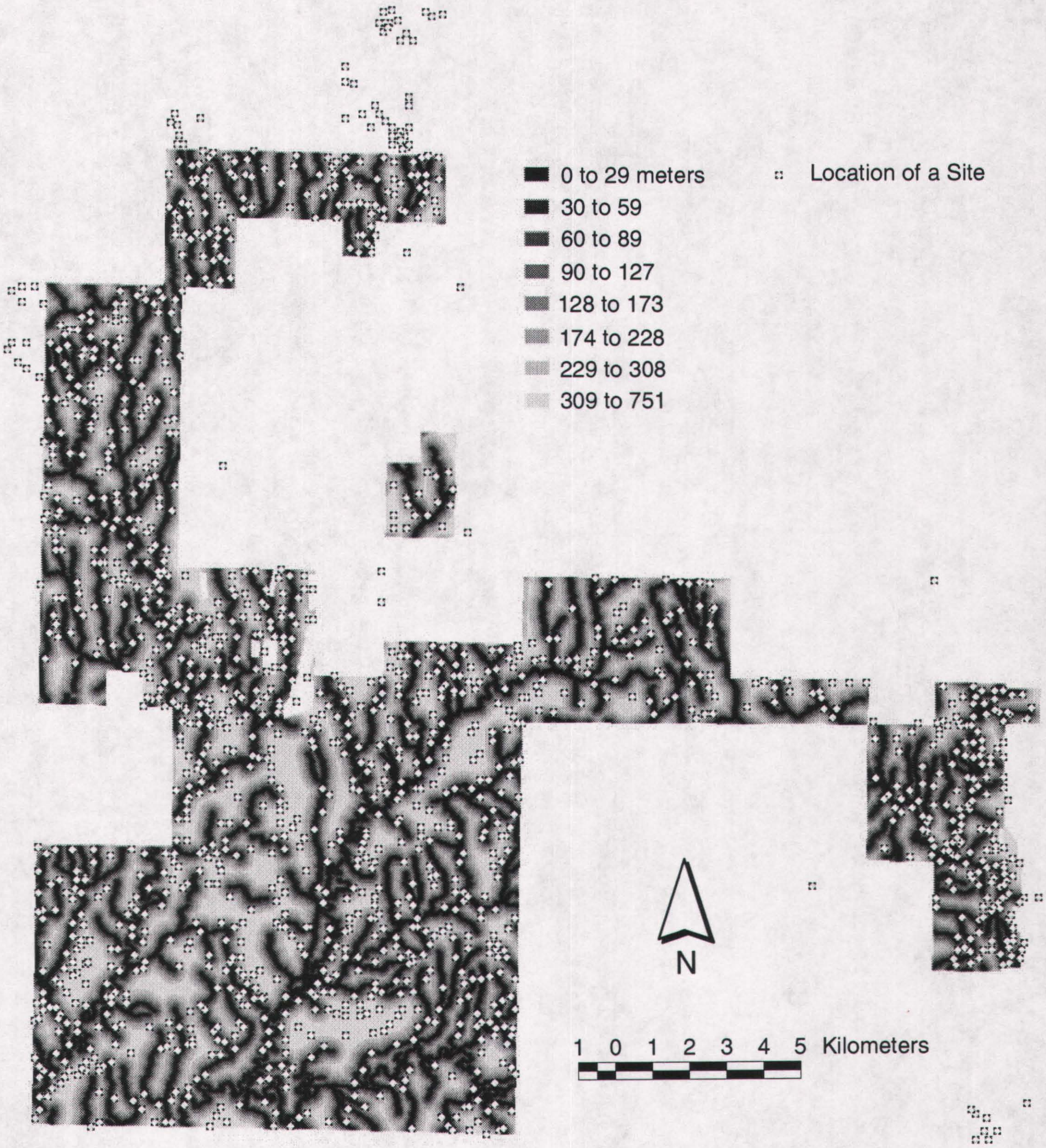

Figure 6.18 Distribution of Precontact Sites Over Classes of Distance from Drainage, East Block.

the Wood Mountain area and its associated landforms. Within this area large trees may grow on the sides of coulees, and in at least one spot a spring provides water. Because trees are relatively rare in the rest of the Park it is natural that this area would have attracted settlement of all kinds. The hill tops within the area also provide good views of the rolling grassy country to the south. These characteristics may have made year round occupation of this area possible. Bison and other game could have wintered in the treed drainages of the area while grazing in the surrounding grasslands in the spring, summer, and fall.

For the West Block analysis indicates that sites tend to be larger as elevation increases. This primarily reflects a pattern observed for stone ring and lithic scatter sites. In general areas which rise above their surroundings were used for more frequent or more intensive occupations. Open and exposed sites suggest a spring to fall occupation. The accompanying view of surrounding areas may reflect a need to observe the local movements of both game and people.

Drainages are another feature that define landforms. For both the East and West Blocks sites tend to be situated anywhere from 30 to 200 meters back from a drainage. This would appear to relate to the observed preference for landscape edges seen particularly among sites with stone rings. In addition areas furthest from a drainage are also positively associated with sites. What may be the case is that we are seeing a preference for two different landforms. Landscape edges are one landform while areas furthest from drainages are most likely hill tops. Sites along a landscape edge may reflect a positioning of sites to take advantage of the resources of both prairie level and drainage bottoms (Dreaver 1980b:10-21). Sites on hill tops may be situated in those locations to be able to monitor game in the uplands.

While water is undeniably an important resource, distance to water sources did not present itself as a major factor in terms of overall site location. The season in which sites were created may have some bearing on this point. Throughout much of the G.N.P. water is available in drainages and sloughs in the spring through to the middle of summer. Groups using the area during this time may not have considered locating sites close to water particularly important.

6.3.2 Sites With Stone Ring Features

It is evident that elevation plays a strong role in the location of stone ring features and the number of rings that are present at a site. A preference for areas of higher elevation is evident for stone ring sites in both the West and East Blocks. This increased elevation corresponds to some degree with an increased view over adjoining areas. Dalla Bona (1993:130) suggests that the location of stone circles on valley edges would have allowed people occupying the site to observe game animals in both valleys and upland areas. Applied to areas of higher elevation in G.N.P., this idea fits. The ability to observe game animals may have been more important than locating camps closer to other resources like water or plant foods.

Large sites in upland areas may correspond to locations where a number of groups camped together likely in the spring or late summer. Large groups of people would have been able to take part in the communal hunting of large bison herds. In the West Block, some large stone ring sites are located near the remnants of bison drives while others are located along coulee or valley rims. Associated with these sites, along the bottom of the valley and coulees, are sites with fire-cracked rock features which may be the remains of processing sites. While bison drive lane segments in both the West and East Block have sites concentrated around them, the large ring sites and associated processing areas not associated with drive lanes suggest that communal hunting occurred in areas not associated with drive lanes. Drive lanes in the Park might have been made out of stone only when this was convenient. According to Arthur (1975:85) drive lanes could be made of any available material including brush, buffalo dung, logs, and heads of snow or dirt. The East Block particularly has a large number of areas where processing sites characterized by fire-cracked rock and bone accumulations associated with large upland stone ring sites are present without visible drive lanes (Figure 6.19). This suggests that in fact communal hunting took place in many areas within the Park but at times used drive lanes made of perishable materials which are no longer visible today.

Aspect is another important factor for habitation sites. Two factors are at work here: prevailing wind direction and exposure to direct sunlight. Of the two, prevailing wind direction

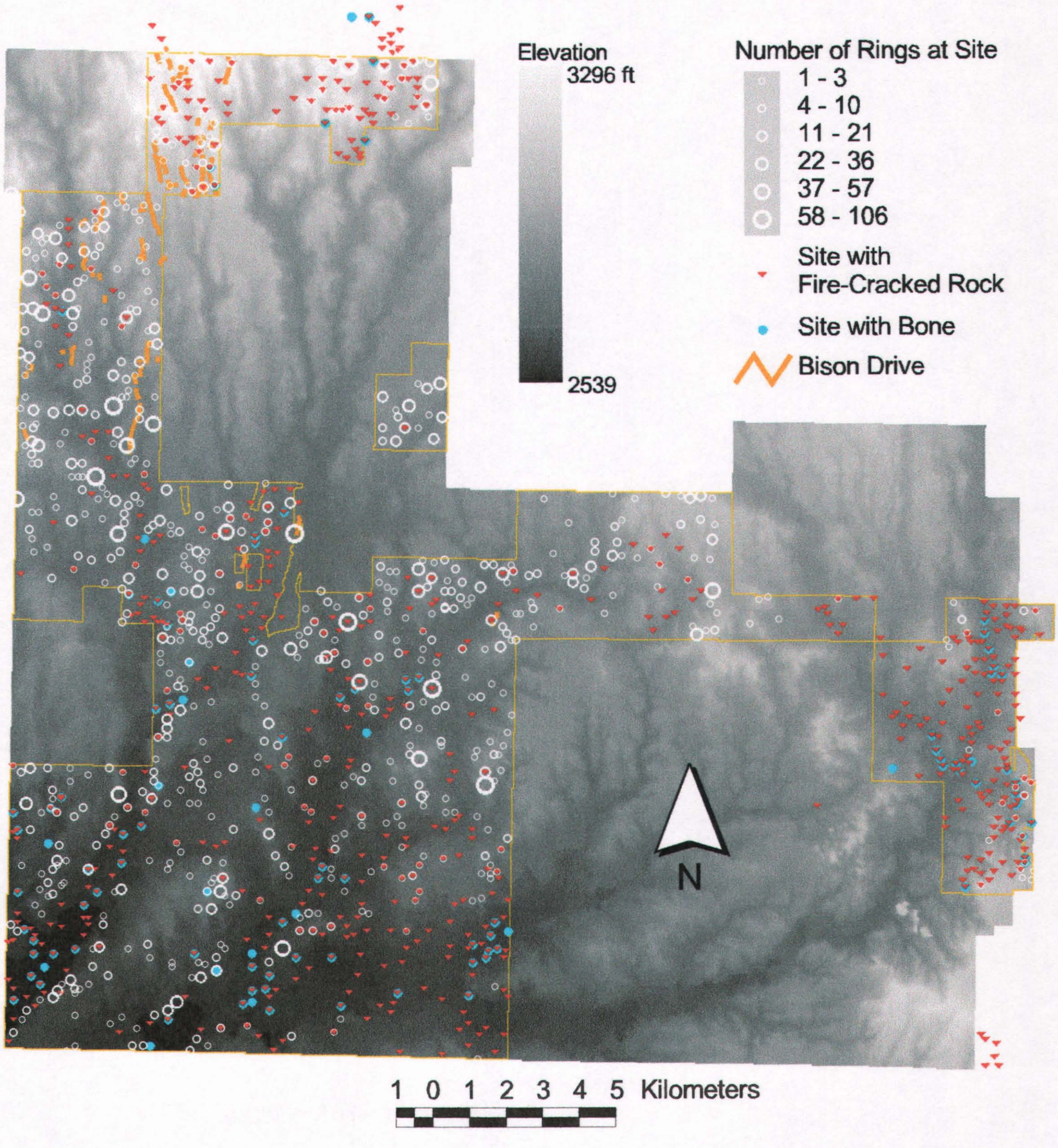

Figure 6.19 Distribution of Sites with Stone Rings, FCR, Bone and Drivelanes Over a Digital Elevation Model, East Block.

appears to be the most important. The East and West Blocks have somewhat different patterns in terms of aspect, but locating stone ring sites out of the prevailing wind appears to be a moderate but significant trend for both of them. The best available data on prevailing wind direction are for Swift Current, about 120 km north of G.N.P. For all seasons, the prevailing wind is from the west.

Aspect is somewhat complex in terms of interpretation because the orientation of landforms to some degree dictate what aspects will be important in a particular area. The northern half of the west part of the West Block is dominated by coulees and uplands running north-south so the area is dominated by east-west aspects (Figure 6.8). This is not the case for areas south of the river valley. The East Block in the large surveyed area in the southwestern portion of the block has landforms which generally run southwest to northeast. However, smaller topographic features tend to run southeast to northwest across this (Figure 6.8). Stone rings relate to aspect as shaped by these landform trends and not strictly to cardinal points of the compass.

This being the case, the associations with aspect in the East Block become a little bit clearer. Stone rings show a weak positive association with northeastern and southeastern aspects and negatively associated with southwestern aspects. As smaller topographic features tend to run northwest to southeast, westerly winds are most likely to hit a southwestern facing slope and areas facing northeast will be more sheltered. The data from the East Block suggest that for habitation sites, windier slopes are being avoided.

The north to south orientation of areas north of the river valley in the West Block means that westerly winds will blow on western slopes. In the West Block we see a preference for eastern, northeastern, and northern slopes, with an avoidance of southern slopes. The preference for eastern slopes again suggests that westerly winds are being avoided.

In some ways areas exposed to wind might seem to be advantageous in that they would have had reduced numbers of biting insects in the summer. High winds may have caused problems for people living in tipis by blowing them over. A summer storm has been known to demolish at least one researcher's tent in G.N.P. The fact that tipis very often had to be held down with stones suggests that wind was a factor. As most of the stone ring sites considered here are found in the open uplands, they represent spring to fall occupations. This suggests that efforts were made to keep camps out of the brunt of the wind on a year round basis, not just in the winter when shelter from winter storms was essential.

The reduced numbers of sites found in southern slopes may be due to an avoidance of direct sunlight during the summer. These areas tend to be hot and dry with sparse vegetation producing less than ideal conditions for a camp. This pattern suggests that the majority of sites with stone rings were produced during warmer seasons. Winter occupations may exist beneath this pattern, but likely having produced fewer sites, contribute less to the main trend.

A comparison of water sources with sites with stone rings shows that there is no straight forward relationship between the distance from water sources and sites with stone ring features. As water is an essential resource it is often assumed that camps would have been placed in close proximity to it (Frison 1991:12). Water is heavy and requires special containers to haul it so at first glance it would seem to be logical that most campsites would be found close to water. The data from both the West and the East Block suggest that this was not always the case.

The idea that camps and water sources are closely related is reflected in historical accounts. Anthony Henday commented during a 1754 journey into the Canadian Plains that "the greatest hardships I have yet experienced is the Warmness of the weather, and the want of Water" (Burpee 1907:332). Peter Fidler summed up the relationship between water sources and encampments during his journey through the plains of Alberta in 1792-93:

> Water being such a very necessary article we are obliged to encamp at particular places, some days journey are long & some short, entirely owing to the places where water is to be had, both for ourselves & for the horses (Haig 1990:25).

An important consideration is that horses would have constituted an additional water requirement which could not easily have been met by carrying water with them.

From the analysis of the locations of sites with stone rings, it is apparent that sites with stone ring features in the West Block are positively associated with permanent water sources as shown on topographic maps, although the association is not strong. Sites with stone rings show a tendency to be located within 1000 meters of a water source, and a tendency not to be within the range of 1500 to 2500 meters from a water source. This does not present an overall pattern where water sources are a critical factor in regard to the location of sites with stone rings. This raises the issue of whether the water sources represented on topographic maps are adequate representations of the water sources which people depended upon in the past. Questions are raised about how water sources in the Park may have changed over time. Another issue is the season in which the Park area was used. The use of spring/seasonal water sources may have greatly affected the pattern of settlement in the Park.

In an effort to gain greater understanding of the relationship between stone rings and water sources remote sensing was used to make alternate maps of water in the Park. Water sources mapped using Landsat TM imagery produced a map of non-alkali seasonal water sources in the West Block. Sites with stone rings showed no statistically significant positive association. Neither were stone rings positively associated with all water sources mapped on topographic maps. Sites with stone rings were, however, positively associated with water mapped using fine beam radar imagery. Each method of mapping produced water maps with distinct characteristics. Topographic maps show most seasonal potholes and drainages as water sources. The Landsat TM map showed the Frenchman River and non-alkali sloughs and potholes as water sources. The radar imagery water map had the best resolution in terms of mapping all sloughs and potholes, including ones which were not on topographic maps. This map did not include drainages as water sources except for the Frenchman River.

The result of all of these comparisons is that stone rings show an association with standing water sources like sloughs and potholes without reference to how alkali they might be. Drainages other than the Frenchman River are not significant water sources. In general, it appears that camps needed to be only in the general vicinity of a water source. Seasonal water sources may have been useful even after surface water had dried up. Mathew Cocking describes digging "in a low plot of ground to obtain water" while travelling with a group of Assiniboin on the plains of Saskatchewan in 1772-73 (Burpee 1908:108).

The fact that sites with stone rings are most closely associated with water sources derived from a map which include the most detailed recording of surface water suggests that many of these sites were created when this surface water was available. Surface water is most available in the West Block during the spring. Water sources were mapped from a radar image taken on April 2nd, 1997. Morgan (1980:152) suggests that bison move onto their summer range in May when blue grama grass begins its new spring growth. Blue grama grass is a dominant species in the uplands of the West Block. G.N.P. may have had large numbers of bison arriving in the late spring. With the new spring growth of blue grama grass, large herds may have occupied both sides of the Frenchman River. After studying a number of soil profiles within the West Block for a study of past fire events, Elena Ponomarenko (Personal Communication 1998) was able to make the following interpretations. Grazing events within the Park were evident within the soil profiles and differences between cattle grazing and bison grazing were distinguishable. Grazing by bison appears to have been intensive, stripping much of the surface vegetation, and seasonal. Trampling evident within the soil profile is characteristic of wet soils. These preliminary results suggest an intensive use of the West Block by bison during the spring. The density of habitation sites around seasonal water sources suggest that groups of people would have followed the bison into the region during the spring and may have participated in communal bison kills.

With the progression of seasons into summer, Morgan (1980:152) suggests that grasses would lose some of their nutritional value and water would be come scarce which would require bison to form smaller herds and move often. While a separate pattern of stone ring sites cannot easily be distinguished in the data from the proposed spring camps, it may have been that there were smaller groups of people camped along the margins of the Frenchman River Valley in later summer where they were not too far from water and would have a view of game travelling in the valley below. Summer groups may have been able to dig some type of well as described above, using areas away from the river. There is some evidence that the Park area was wetter at some time in the past. In a recent investigation, Elena Ponomarenko (Personal Communication 1998) noted that in some sloughs in the West Block cycles of clay, silt and sand deposition were evident, indicating that the slough dried out seasonally, but below these levels were layers of continuous clay indicating that water stood in the slough year-round. This being the case, the Frenchman River can no longer be considered the only source of year-round water which existed in the Park in the past. The fact that alternate water sources were available year-round could also explain the lack of clustering of stone ring sites along the edges of the Frenchman River. Chappice Lake (Vance et al. 1992), Harris Lake (Sauchyn 1990) and Moon Lake (Haskell et al. 1996) all show moister periods prior to the present, anywhere form 4000 to 1000 years B.P. (see figure 1.19). It may be that climates within the last 3000 years have tended to be wetter than they area now and that this resulted in more surface water within the Park.

The East Block does not conform to expected relationships. Areas closest to permanent water are negatively associated with sites with stone rings while areas further away are positively associated with sites with stone rings. It is likely that topographic maps do not provide a detailed enough map of water to reflect the water sources people used. People may have had water sources which remain unmapped. As noted above the Park area appears to have been wetter in the past which would have led to greater water resources within the East Block. Springs are generally unmapped for G.N.P. yet these are known to have been an important water source historically. Peter Fidler mentions camping near springs during his 1792-93 journey through the Alberta plains and notes that the Peigan people he was travelling with knew the exact location of each of the springs (Haig 1990:25,28,72). Fidler mentions the use of springs in the winter, suggesting springs were important sources of water in the winter as well as warmer seasons (Haig 1990:72). Henday also mentions camping by a spring during his journey of 1754-55 onto the Canadian Plains (Burpee 1907:329).

Bearing these points in mind, landforms are still a very strong factor in the location of stone rings in the Park. What may be required is a contemplation of how people in the past perceived distance. For people who literally walked across large sections of the continent, walking one kilometre over moderate terrain to obtain water may not have seemed a particularly great distance to go. Ultimately upland landforms which provided some visibility of game animals may have been a more important factor in the location of campsites. Henday noted in 1754 that camps were often put on open plains to avoid surprise attacks by enemies (Burpee 1907:339). The ability to survey surrounding areas for both game and potential enemies may have been give greater consideration in locating campsites than a convenient access to water. Bison may have travelled to the East Block for the same spring grasses that grow in the West Block. Herds of bison in the East Block in the spring may have attracted groups of people as reflected by large numbers of stone ring sites located along drainages with seasonally available water.

6.3.3 Sites with Lithic Scatter Features

The data available on lithic scatter features were general. Within the GIS data base, the presence or absence of a lithic scatter at a site was recorded as well as the area of the site where the lithic scatter feature occurred. This precluded an analysis of the distribution of different lithic material types.

Elevation plays a strong role in the distribution of sites with lithic scatters in the West Block but less so in the East Block. In the West Block sites with lithic scatter features are associated strongly with lower elevations, in other words, the valley and coulee bottoms. This may be a result of a number of factors. It may be that lithic material sources tend to lie at lower elevations in the West Block but no map of lithic sources exists. As can be observed by anyone visiting the West Block, large quartzite cobbles which sometimes show signs of cultural modification can be found quite easily in the uplands. As the largest portion of lithic scatter sites are made up of quartzite debitage (Adams and Filopoulos 1995:65), lithic material source location would not explain lithic scatter site location.

A trend apparent in both the West and East Blocks is an association between sites with lithic scatter features and permanent water sources. This pattern is to some degree similar to the locations of sites with fire-cracked rock. One explanation for this pattern would be that sites with lithic scatters are associated with the boiling and processing activities at sites with fire-cracked rock or may occur at the same sites (in the West Block sites with fire-cracked rock tend to occur at lower elevations). Adding to this picture is that there is a strong association between lithic scatter site area and elevation in the West Block. As elevation increases, so does the size of the lithic scatter.

The following explanation for these patterns is proposed. Numerous small sites with lithic scatter features are associated with processing activities, represented by sites with bone and fire-cracked rock features, which are located in the valleys and near permanent water. These sites are likely the result of the need to make or resharpen tools which were needed but were not on hand. These tools likely had a coarse butchering or bone-smashing function. At higher elevations, larger camps are more numerous and lithic scatters are proportionately fewer than in the valley but are larger. It may have been that the task of working stone into usable tools or tool blanks was situated not far from camp. These tools may have been made of finer material, required more time and concentration to make, and may have had more of a sophisticated function (e.g. projectile points, scrapers or gravers). A mapping lithic scatters by material type would be a test of the above interpretation. In sum, the differences in size and number of sites with lithic scatters as they are distributed over the landscape may represent lithic scatter produced through different functions.

6.3.4 Sites with fire-cracked rock features

Elevation and distance from a water source are the two factors which are the most strongly associated with sites with fire-cracked rock. For both the West and East blocks, fire-cracked rock is positively associated with lower elevations and negatively associated with areas of a mid-range elevation. Areas of lowest elevation tend to correspond with valley or large coulee bottoms most of which would have held water at some time during the year. In addition to access to water, these areas may have been the logical locations for bison kill processing activities. The occurrence of bone in sites with fire-cracked rock in the bottoms of valleys and coulees tend to confirm this interpretation (Figure 6.20). In the West Block bison drives in the uplands terminate at the edges of the Frenchman River Valley and other large coulees. Overall, the position of sites with fire-cracked rock in the landscape suggests that the majority of sites with fire-cracked rock were produced through kill processing activities. Specifically, bone was boiled in water using heated rocks to extract grease. Brumley and Dau (1988:83) suggest that meat was also cooked this way for immediate consumption or subsequent drying.

Water sources show an interesting range of associations. In both the West and East Blocks there is a strong positive association with permanent water sources. This contrasts with sites with stone rings which had no such strong association. In addition, sites with fire-cracked rock features in the West Block show a stronger positive association with non-alkali water sources identified via Landsat TM imagery than with permanent water sources identified via the topographic map. What is suggested by these associations is that water boiling operations which produced fire-cracked rock required a source of reasonably good quality water in large amounts. Unlike general drinking water which might be obtained in small amounts through wet soils, boiling operations for grease extraction or other activities would have required a significant amount of water at hand. The quality of water as well as the presence or absence of a water source appears to have a bearing on the location of sites with fire-cracked rock. In addition, sites near wood would have been required as heating stones requires a lot of fuel energy (Brumley and Dau 1988:83).

Fire-cracked rock could have been produced in sites throughout the year. The association of sites with fire-cracked rock with many of the relatively year-round water sources suggests that they could have been produced during the dry summer and fall periods, as well as spring. Fire-cracked rock produced by hearths in winter camps near a water sources may have contributed to the distribution of sites with fire-cracked rock as well.

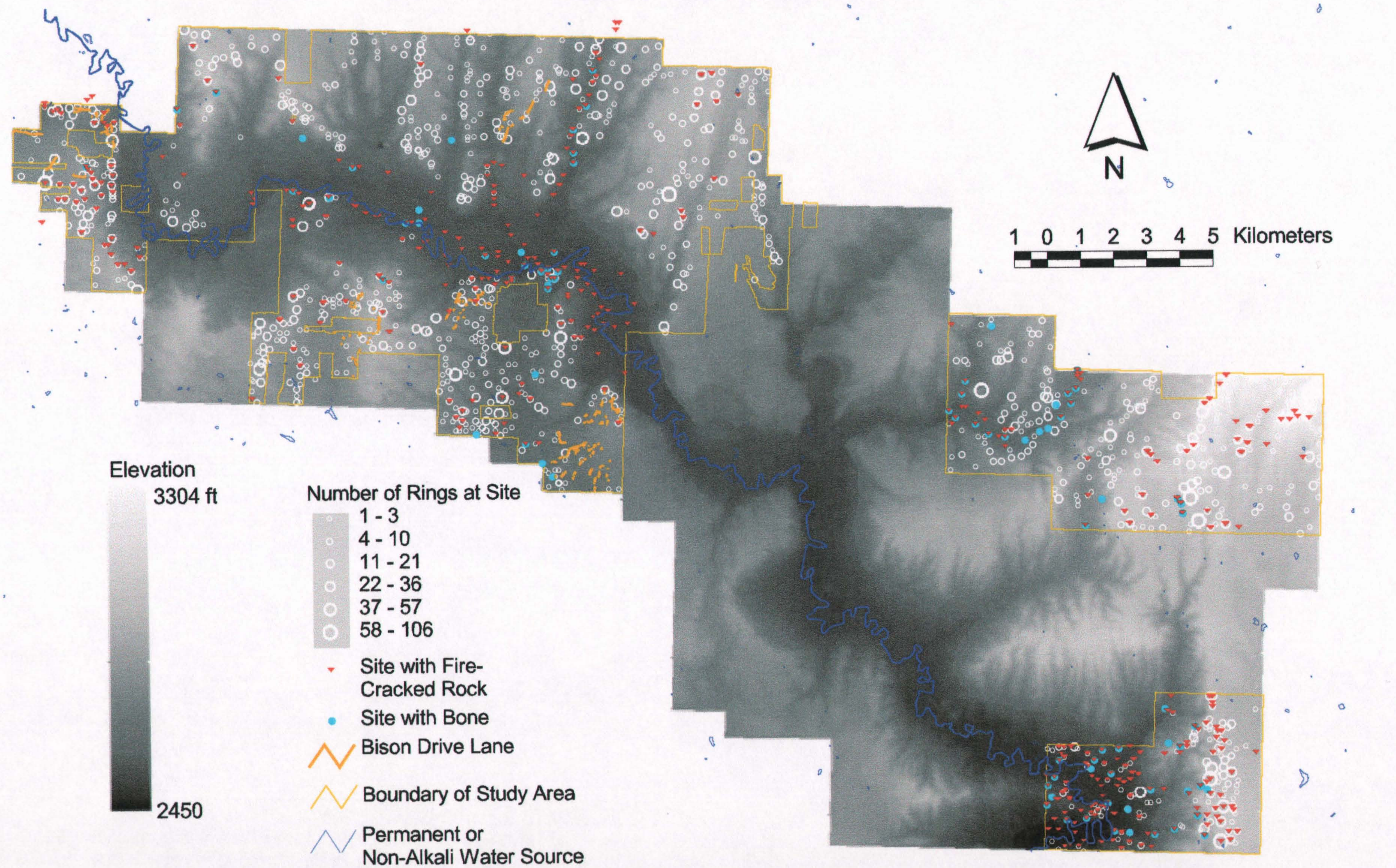

Figure 6.20 Distribution of Sites with Stone Rings, FCR, Bone, and Drivelanes Over a Digital Elevation Model of The West Block.

6.3.5 Hearths

Hearths are the least patterned feature type used in this analysis. In the West Block elevation and slope appear to have some bearing on hearth locations while in the East Block no chi-square tests produced statistically significant results. The most likely explanation for this lack of patterning is that sites with hearth features could have been produced by many different activities in different seasons. Virtually any type of site might possess a hearth of some kind. This seems to have produced a series of overlapping patterns which when combined produce a distribution approximating randomness.

7.0 Patterns of Site Location Compared to Elements of Flora and Fauna

The availability of a detailed vegetation map goes beyond the standard datasets commonly available for GIS Regional Analysis projects. However, for this thesis it has been possible to extend the analysis of site locations beyond topographic variables to include some elements of flora and fauna. Three themes were looked at: 1. site associations with vegetation communities, 2. with food plants and 3. with a model of bison forage areas.

Similar to chapter six, chapter seven is split into two sections. The first section presents the results of statistical comparisons of site and feature locations with elements of flora and fauna and the second section presents interpretations for these findings.

7.1 Results of Comparisons of Site and Feature Locations with Flora and Fauna

7.1.1 Patterns of Site Location compared with Different Vegetation Communities

Vegetation in the Park was mapped by defining areas of particular vegetation communities and combinations of these communities. While the distribution of all floral species for all areas is not known, the dominant floral species is recorded for each area that was mapped. A list of species mapped in G.N.P. is given in table 7.1. For this analysis only overall sites and sites with stone ring features were considered in the West Block. In the East Block, sites with fire-cracked rock could be included. This decision was based on the fact that the large number of vegetation communities mapped in the Park translated into a large number of classes for analysis. The high number of classes in turn required a large site sample in order that the test remain statistically valid. Only sites overall and stone ring sites were of a sufficiently large sample in the West Block. In the East Block fire-cracked rock could be included.

Table 7.1 Vegetation Mapping Classes Used to Map Vegetation in Grasslands National Park.

Map Class	Vegetation Code	Vegetation Type(s)	Scientific Names
1	E	Rose/Winterfat	*Rose sp.*
			Eurotia lanata
		Juniper/Golden Bean	*Juniperus sp.*
			Thermosi rhombifolia
		Moss Phlox/Rubberweed	*Pholx hoodii*
			Hymenoxis richardsonii
		Rillscale/Povertyweed	*Atriplex dioica*
			Monolepis nuttalliana
		Rabbit Brush/Povertyweed	*Chrysothamnus nauseosus*
			Iva axillaris
2	SB	Speargrass/Blue Grama	*Stipa comata*
			Bouteloua gracilis
		Speargrass/Blue Grama / Western Wheatgrass	*Stipa comata*
			Bouteloua gracilis
			Agropyron smithii
		Porcupine Grass/Prairie Sage	*Stipa spartea*
			Artemisia ludovicina
3	D-F	Disturbed: Russian Wild Rye	*Elymusjunceus*
		Crested Wheatgrass	*Agropyron pectiniforme*
		Pasture Sage/Blue Grama	*Artemisia frigida*
			Bouteloua gracilis
4	SB/ASA	Mixed vegetation types	
5	D-C	Disturbed: Summer-Cypress	*Kochia scoparia*
6	JS	Creeping Juniper/Speargrass	*Juniperus horizontalis*
			Stipa sp.
7	AC	Western Wheatgrass/Sedge	*Agropyron smithii*
			Carex sp.
8	ASA	Pasture Sage/Speargrass/ Blue Grama	*Artemisia frigida*
			Stipa comata
			Bouteloua gracilis
		Pasture Sage/Green Needle Grass/Western Wheatgrass	*Artemisia frigida*
			Stipa viridula
			Agropyron smithii
9	RS	Rose/Buckbrush	*Rose sp.*
			Symphoricarpos occidentalis
10	SA	Greasewood/Rillscale	*Sarcobatus vermiculatus*
			Atriplex nuttallii
11	AAO	Sagebrush/Western Wheatgrass/Prickly Pear Cactus	*Artemisia sp.*
			Agropyron smithii
			Opuntia polycantha
12	RS/SaS	Mixed vegetation types	
13	SA/AAO	Mixed vegetation types	
14	JS/E	Mixed vegetation types	
15	RS/SA	Mixed vegetation types	
16	JS/ASA	Mixed vegetation types	

(Table 7.1 Continued)

Map Class	Vegetation Code	Vegetation Type(s)	Scientific Names
17	JS/RS	Mixed vegetation types	
18	ASA/JS	Mixed vegetation types	
19	PSV	Trembling Aspen/Buckbrush/ Violet	*Populus tremuloides* *Symphoricarpos occidentalis* *Viola sp.*
20	AA	Disturbed: Pasture Sage/ Western Wheatgrass	*Artemisia frigida* *Agropyron smithii*
21	APR	Saskatoon/Chokecherry/ Canada Gooseberry	*Amelanchier alnifolia* *Prunus virginiana* *Ribes oxycanthoides*
22	ShS	Thorny Buffaloberry/ Buckbrush	*Shepherdia argentia* *Symphoricarpos occidentalis*
23	SaS	Willow/Buckbrush	*Salix sp.* *Symphoricarpos occidentalis*
24	E/JS	Mixed vegetation types	
25	HR	Foxtail Barley/Dock	*Hordeum jubatum* *Rumex sp.*
26	AAO/RS	Mixed vegetation types	
27	Sas/ShS	Mixed vegetation types	
28	RS/PSV	Mixed vegetation types	
29	AAO/SA	Mixed vegetation types	
30	DP	Alkali Grass/Nuttail's Salt Meadow Grass	*Distichlis spicata var. stricta* *Puccinellia nuttalliana*
31	AC/HR	Mixed vegetation types	
32	HR/AC	Mixed vegetation types	
33	SB/AC	Mixed vegetation types	
34	ASA/D-F	Mixed vegetation types	
35	PR	Shrubby Cinquefoil/Rose	*Potentilla fruticosa* *Rose sp.*
36	ASA/RS	Mixed vegetation types	
37	E/ASA	Mixed vegetation types	
38	RS/DP	Mixed vegetation types	
39	SB/E	Mixed vegetation types	
40	SB/HR/AC	Mixed vegetation types	
41	RS/PR	Mixed vegetation types	
42	RS/ASA	Mixed vegetation types	
43	PR/RS	Mixed vegetation types	
44	AAO/ASA	Mixed vegetation types	
45	SB/AAO	Mixed vegetation types	
46	AAO/SB	Mixed vegetation types	
47	ShS/RS	Mixed vegetation types	
48	AR	Manitoba Maple/Canada Gooseberry	*Acer negundo* *Ribes oxycanthoides*

A requirement for chi-square tests to remain valid is that all classes must have an expected value of one or greater and not more than 20 percent of classes may have an expected value of less than five (Ebdon 1985:67). In order to conform to these requirements, some vegetation classes had to be grouped together. Classes with similar vegetation types were grouped together to produce simplified vegetation maps which met all the statistical requirements. Grouping of vegetation classes was done on the basis of two criteria: vegetation classes with common vegetation types and vegetation classes with similar vegetation types were grouped together as required. Vegetation classes which were too small to be statistically valid were grouped with the largest vegetation class containing the same dominant vegetation types. For example, in the West Block class 37 which has E/ASA vegetation types (see table 7.1 for explanation of vegetation types) is 0.079166 square kilometres in size and must be grouped with another class. It is combined with class one which has vegetation type E. The resulting combination is still largely representative of E type vegetation. Table 7.2 provides a list of grouped vegetation classes. In some cases it was not possible to combine classes with the same vegetation type. In this case vegetation with similar

Table 7.2 Vegetation Classes Combined to Produce Final Map Classes

West Block		East Block	
Final Map Class	Vegetation Classes Combined with Final Map Class	Final Map Class	Vegetation Classes Combined with Final Map Class
1 E	37 E/ASA	1 E	24 E.JS
2 SB	45 SB/AAO		37 E.ASA
6 JS	16 JS/ASA	2 SB	39 SB.E
	17 JS/RS		45 SB.AAO
8 ASA	7 AC	6 JS	14 JS.E
	18 ASA/JS	8 ASA	36 ASA.RS
	34 ASA/D-F	9 RS	38 RS.DP
	36 ASA/RS		41 RS.PR
9 RS	12 RS/SaS		42 RS.ASA
	15 RS/SA	10 SA	13 SA.AAO
	28 RS/PSV	11 AAO	44 AAO.ASA
10 SA	13 SA/AAO		46 AAO.SB
22 ShS	19 PSV	19 PSV	21 APR
	47 ShS.RS		27 SaS.ShS
25 HR	31 AC.HR	35 PR	43 PR.RS
	32 HR.AC	40 SB.HR.AC	25 HR
27 SaS.ShS	23 SaS		

Note: Refer to Table 7.1 for definitions of vegetation classes

characteristics was combined (a bushy/woody type vegetation class would be combined with another bushy/woody class). An example from the East Block is a combination of class 21 (Saskatoon/Chokecherry/Gooseberry) with class 19 (Trembling Aspen/Buckbrush/Violet). These combined classes did not make up significant portions of the area under analysis.

The West Block

Strong relationships between vegetation type and site location were observed for the West Block. The results of chi-square tests are given in Table A65 and A66. Site locations overall show a strong positive association with grassy areas (class 2, class 4, class 8) which are dominated by speargrass and blue grama-grass as well as prairie and pasture sage. Vegetation with negative associations include classes 1, 9-11, 20-22 and 27. Most strongly negative is class 1 which is a rose/juniper/rabbitbrush vegetation type, followed by class 11 which is a sagebrush/western wheatgrass/prickly pear cactus vegetation type. Classes 9 (rose and buckbrush), 21 (saskatoons, chokecherries and gooseberries) and 22 (buffaloberry and buckbrush) are bushy vegetation types which all show a negative association.

Surface visibility and erosion likely play some part in this distribution. Thick bush has no surface visibility and would have required sub-surface testing to find sites. This may mean that there were sites in bushy areas, particularly if areas had been less densely covered by bush in the past. On the other hand, it may have been that resources from bushy areas were used (such as collecting berries) but these activities left no preserved remains. The hordes of mosquitoes which inhabit these areas may have made camping or other activities very unpleasant during the summer.

Areas with sparse vegetation may have been subject to greater effects from erosion than other areas. Figure 5.3 provides an example of an area with sparse vegetation and the accompanying eroded soil. The reduced proportion of sites in areas with rose, juniper, sagebrush and cactus may reflect the erosion of sites in these areas and their eventual loss of some of them. While features like stone rings could become displaced and unrecognizable through erosion, it is unlikely that lithic scatters and fire-cracked rock features would have been completely displaced.

The question that is raised is whether sites would have been located in these areas in the first place as they are not particularly pleasant places to be and have few apparent resources.

Sites with stone ring features follow the same general pattern as the overall site pattern. The difference is that the location of sites with stone rings show a significantly stronger relationship to vegetation types than do sites overall. Half of the sites with stone rings occur within the vegetation type dominated by speargrass and blue grama-grass (class 2) which covers only 31 percent of the study area (Figure 7.1).

The East Block

The relationship between site locations and vegetation is less strong for the East Block than for the West Block. Results of chi-square tests are given in Table A67 to A69. Sites overall show a positive association with class one vegetation types (rose, juniper and rabbitbrush). This is opposite to the trend in the West Block. Grass species are generally not significant in site location, while a class combining speargrass, blue grama-grass, dock and sedges (class 40) is negatively associated with sites.

Sites with stone ring features revert once again to the pattern observed from the West Block where grasses and juniper/grass mixtures (classes 2 and six) are positively associated with stone ring sites while rose and other dry area vegetation types (classes nine to eleven) and wooded areas (class 19) are negatively associated (Figure 7.2). What is apparent is that similar vegetation types were significant in terms of stone ring locations for both the West and East Blocks.

In the East Block, sites with fire-cracked rock features are positively associated with dry area type vegetation like rose, sage and greasewood (Figure 7.2). Very grassy areas are negatively associated. This corresponds with previously observed patterns where fire-cracked rock is less common in grassy upland areas than valley and coulee bottoms. Interestingly, alkali grasses are negatively associated with fire-cracked rock. This supports the idea that activities creating fire-cracked rock required non-alkali water sources as observed in the previous chapter.

Figure 7.1 Distribution of Sites with Stone Rings Over Vegetation Classes, West Block.

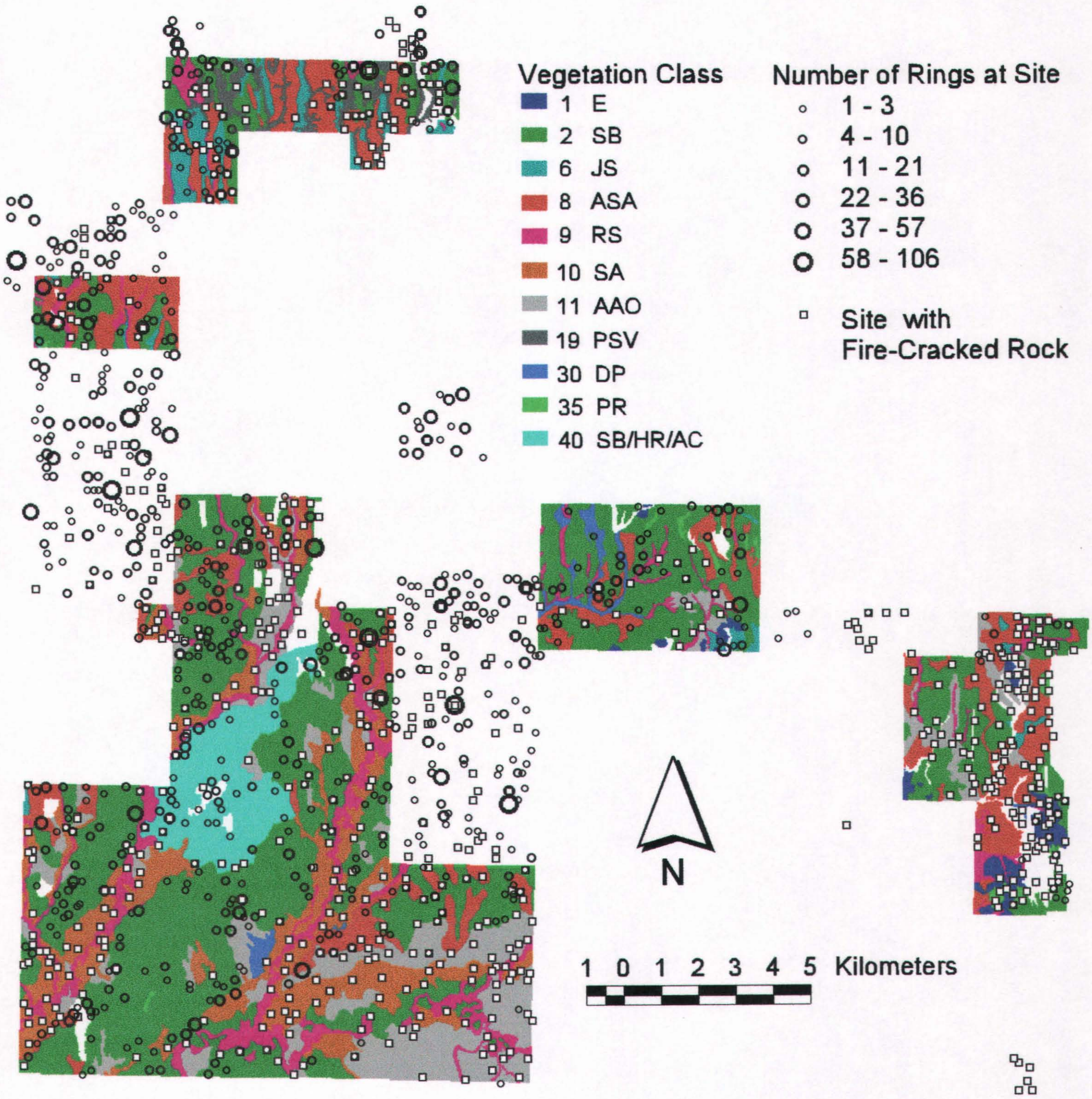

Figure 7.2 Distribution of Sites with Stone Rings and Sites with FCR Over Vegetation Classes, East Block.

7.1.2 A Comparison of Food Plants and Site Location

Plants which constituted major or minor food sources for plains groups were compiled from Peacock (1992) and Leighton (n.d.). Peacock's study is based on an ethnography of the Piikáni people (part of the Blackfoot Nation) while Leighton relies on historical and ethnographic sources for her study. Plants were assigned a somewhat subjective value according to their value as food described by Peacock and Leighton so that saskatoon berries for example would have a high value while rosehips would have a lower value. Plants which were known to be stored as food were assigned higher values. Unfortunately, some plants known to have been important food sources were not listed as major species in the G.N.P. vegetation survey. The distribution of the prairie turnip, for example, is not known. This seriously hampers a proper understanding of the relationship between site locations and plant food sources. In the end, all significant plants that were listed in the vegetation survey were assigned a value. The cumulative value of all significant plants was then mapped to produce a map presumably representing important plant food sources. Table 7.3 provides a listing of plants used and their assigned values.

Table7.3 Species Used in Plant Food Maps and Assigned Values.

Scientific Name	Common Name	Value
Amelanchier alnifolia	Saskatoon	6
Populus tremuloides	Trembling Aspen	2
Prunus virginiana	Chokecherry	6
Rose sp.	Rose	4
Rumex sp.	Dock	2
Shepherdia argentia	Buffaloberry	6

It was found that sites have no obvious relationship to mapped food plants. It may be that species which are essential to our understanding of how site locations relate to food plants are missing from the map because they were not listed by the G.N.P. vegetation survey. Another possibility is that it was only required that sites be located in the general area of food plants and that the requirements for an encampment or other activity did not require ready access to food plants. Seasonality also plays a role. Most plant resources are seasonal. If people were using an area of the Park when a particular food plant species was out of season, it would likely be ignored.

In the end it is not possible to reach a satisfactory conclusion concerning the distribution of food plants and site locations. It may have been that other resources played a greater role in determining site locations or it may be that the biases inherent in the map of food plants preclude a proper analysis.

7.1.3 Patterns of Site Location compared with the Bison Forage Model

In order to try and understand the relationship between site locations and bison habitat, a simple model of areas containing preferred bison forage plant species was constructed. In general, bison primarily feed on grasses and sedges (Tesky 1995). A study of bison diet on the short grass plains of Colorado found that in an area dominated by grass species, bison ate primarily grasses and not sedges (Peden 1976:229). In this case blue grama grass and buffalo grass made up most of the bison diet (Peden 1976:228). Seasonal differences in species eaten are significant (Peden 1976) and diet is also heavily affected by the dominant vegetation of the region (Tesky 1995).

Based on Peden's study of bison diet on short grass prairie (1976), areas dominated by speargrass-blue grama vegetation types and western wheatgrass-sedge sp. were classified as included in the model. In addition to this, some aspects of topography were worked into the model. From a topographic standpoint, bison prefer open spaces (Tesky 1995). For this reason, areas with greater than ten degrees slope were excluded from the model area.

After an initial comparison of site locations with the model, it was noticed that many sites lay along the margins of the model area. To try and measure this trend a 150 meter buffer zone was placed around the model area. In practice, 30 meter resolution cells cannot accurately represent a 150 meter buffer. The result is a buffer which is as close to 150 meters as can be accommodated by 30 meter cells. The final map consists of three areas: areas outside the bison habitat model, areas inside the model and areas which lie 150 meters from the edge of the model area.

The West Block

For both the West and East Blocks, only stone ring, lithic scatter and sites with fire-cracked rock were looked at. Tables A70 to A72 show the results of the chi-square tests for the West Block.

The relationship between the bison forage model and sites with stone rings is the strongest yet analysed. Sites with stone rings are negatively associated with areas outside the model, positively associated with areas inside the model, but most strongly associated with areas in the buffer zone (Figure 7.3). A statistically significant result never proves that one variable causes the other. This being the case it is not easy to determine what factors other than bison habitat might be involved. The number of rings at a site was also compared with the bison forage model and the results are presented in table B7. In general, more of the larger stone ring sites are located in the model area and the buffer zone than areas outside the model. Sites with lithic scatter features show a similar pattern to sites with stone ring features but the relationship to the bison forage model is much less strong. Sites with lithic scatters are negatively associated with areas outside the model and positively associated with areas in the buffer zone. It seems likely that the sites with lithic scatters which lie in the buffer zone are connected to or the same as the large numbers of sites with stone rings found there.

The East Block

The East Block presents a slightly different picture than the West Block. The results of chi-square tests are given in tables A73 to A75.

Stone ring sites show a strong negative association with areas outside the bison forage model and positive associations with the buffer zone as well as the model itself. This time, stone

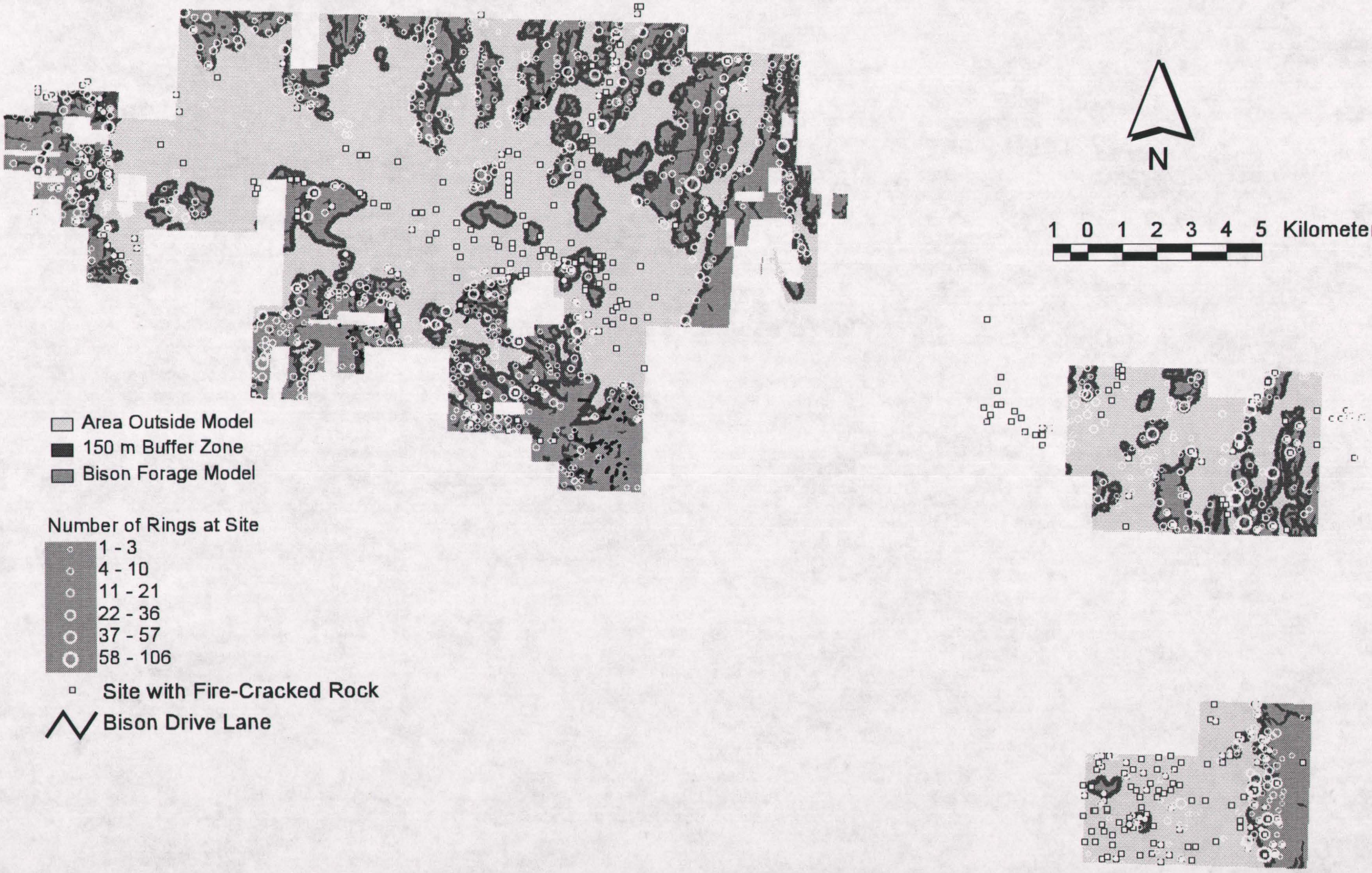

Figure 7.3 Distribution of Sites with Stone Rings, Sites with FCR, and Drivelanes Over Bison Forage Model Classes, West Block.

ring sites are more strongly associated with the model area than with the buffer zone. The overall relationship between sites with stone rings and the bison forage model is less strong than in the West Block. This may be due to the fact that the model in the East Block may be less successful at modelling bison habitat than the model in the West Block. In Figure 7.3 it can be observed how the mapped bison drive lanes correspond quite well with model areas in the West Block. In the East Block (Figure 7.4), many mapped drive lanes lie outside of the vegetation data. Those lanes which do overlap with the vegetation data (and so overlap with the area of analysis) are mostly in the north end of the Park. As previously mentioned this area corresponds to the beginning of the landforms and environment of Wood Mountain. This could mean that bison forage in this area might be comprised of slightly different species than those selected for the model. When drive lanes were visually compared with vegetation data, it was apparent that juniper/grass (class six) and particularly sage/grass (class eight) vegetation types were associated with drive lanes. Wetter climates in the past may have meant that these areas were more grassy or they may have been grazed by bison even though they are not as grassy as other areas. These conclusions depend on the assumption that bison drive lanes are found mainly in areas with good bison forage.

In the East Block sites with lithic scatters and sites with fire-cracked rock show similar patterns in relation to the model. Both feature types are positively associated with areas outside the model, show no relationship to the buffer zone, and are negatively associated with areas inside the model. Areas outside the model often correspond with drainages and areas of low elevation. Since sites with fire-cracked rock are located at lower elevations near drainages, their observed pattern is not surprising. Sites with lithic scatters would seem in this case to be associated with or the same as the sites with fire-cracked rock.

7.2 Interpreting Results

As the analysis of relationships to food plants did not produce results of any significance, only the analysis of relationships to vegetation and the bison forage model will be considered here.

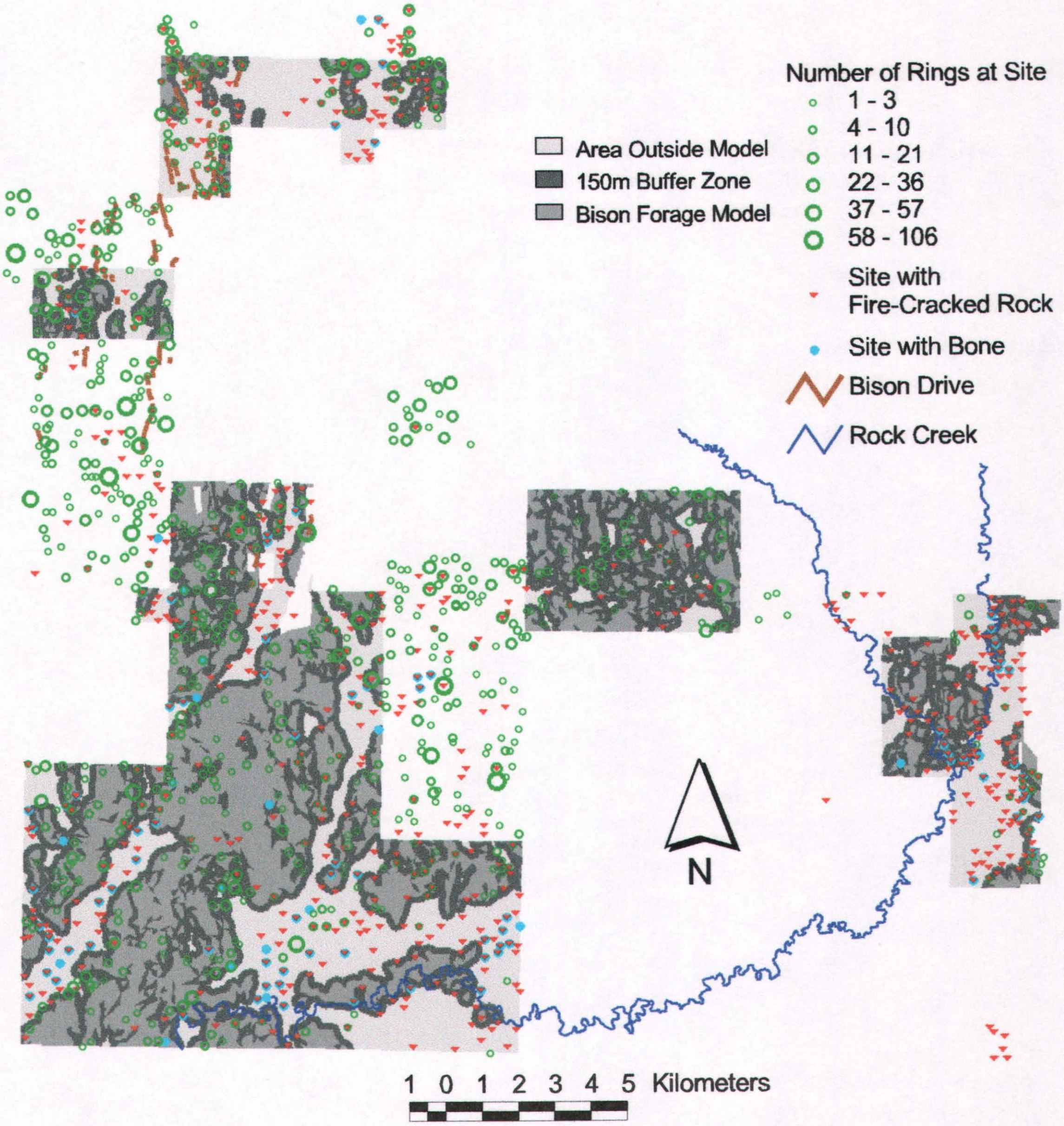

Figure 7.4 Distribution of Sites with Stone Rings, Sites with FCR and Drivelanes Over Bison Forage Model Classes, East Block.

7.2.1 Overall Site Location

The only comparison made of the distribution of sites overall was with vegetation. What becomes clear is that the overall site distribution in the West or East Block in reality reflects the sum of the feature distribution patterns contained within it. In the West Block, sites with stone rings are the most common type of features. Not surprisingly, the relationship between sites overall and vegetation resembles the pattern seen among sites with stone rings. In the East Block there are slightly more sites with fire-cracked rock than stone ring sites. The result is that overall site distribution tends to reflect the strongest associations observed for either fire-cracked rock or sites with stone rings. What is evident is that major trends which apply to all sites are lacking in the comparison with vegetation types.

7.2.2 Stone Ring Sites

Vegetation

A particular issue within the analysis of the relationship between site location and vegetation is that it is not always clear why particular associations exist. One way to look at vegetation would be from a resource perspective. Vegetation would have provided a large number of resources including food, wood for constructing structures or implements, and medicine. Vegetation often defines the habitats that game animals occupy. For this study, the resource aspect of vegetation has largely been looked at with analyses separate from the analysis of site location patterns and vegetation.

Another way of looking at vegetation is to consider it an indicator of environmental conditions. Vegetation communities tend to occupy specific areas based on factors like soil type, water availability, intensity of sunlight, topography and degree of ground disturbance. In a sense, vegetation reflects the micro-environment of a given area. Having a sense of what environment is reflected by particular vegetation types enables one to draw some conclusions as to why sites show an association with certain vegetation types and not others.

In the West Block vegetation which is related to stone ring locations sorts into three general categories: grasses, dry/eroded area vegetation like cactus, juniper, rose and sage, and bushy/

woody type vegetation. Rose is often found with bushy vegetation types in addition to being found on eroded slopes. A strong positive association exists between sites with stone rings and grassy areas. This suggests that in general, sites with stone rings were located in open areas without sharp slopes. Grassy environments also suggest a warm season use of sites with stone rings. Firewood for heating and cooking in the winter would not be available in these areas and neither would trees provide shelter.

Dry/eroded vegetation often reflects a harsher environment, in general areas with little water and possibly loose soil or eroded slopes. The proportionate lack of stone ring or habitation sites in these areas appears to reflect these characteristics. In the West Block, particularly class 1 vegetation types (rose, juniper, rillscale, rabbitbrush) are associated with dry slopes with little vegetation cover. These conditions may have discouraged the use of such areas for activities other than the individual hunting of game or gathering the occasional useful plant.

Bushy/woody vegetation tends to be located near water or at the bottoms of drainages. A combination of the difficulty of locating sites in these areas along with a cultural pattern of limited prolonged use seems to have reduced the relative number of sites found in these areas.

Stone ring sites in the East Block show a similar relationship to vegetation types. Grassy areas have larger proportions of stone ring sites while areas particularly with greasewood and cactus are negatively associated. Wooded areas and shrubby stream bank vegetation (classes nineteen and nine) are also negatively associated. The similarity to the results from the West Block suggest that similar relationships between stone ring site locations and vegetation exist for both the East and West Blocks.

The Bison Forage Model

The Bison forage model seems to clarify some of the relationships between stone ring sites and vegetation. In the West Block, sites with stone rings are strongly positively associated with the bison model area and particularly the margins of this area. If this truly represents a relationship with bison habitat and not some other factor, this pattern suggests that camps were situated in close proximity to areas where bison would likely be. The particular positive association with the buffer zone may indicate that camps were situated so that grazing bison might be observed but would not be disrupted. In general stone ring sites show a very close correlation with the bison forage model and buffer zone regardless of whether these areas are located in the valley or uplands. What is evident is that habitation sites (as represented by stone rings) are very much keyed to the grazing habitats of bison, much more so than to the habitats of other game. In Figure 7.5 it is apparent that some stone ring sites show a tendency to be located at the terminus of bison drives and not in the areas which would likely have been gathering basins. This pattern suggests that encampments were located so that they were relatively near to communal hunting in the uplands. Other parts of the bison forage model, even areas far from valley or coulee edges, also have many sites with stone rings. This suggests that hunting methods other than bison jumps or pound were also being intensively used. The rolling knob and kettle terrain in the southern part of the west half of the West Block is very densely covered with stone rings sites. Bison may have made use of these areas in the spring and early summer when surface water was commonly available. As mentioned in section 6.3.2, water appears to have been less seasonal at times in the past which may have meant that bison stayed in the area throughout the summer. Groups may have used these rolling topography in these areas as part of the surround hunting method. According to Verbicky-Todd (1984:136-137), Native groups used natural terrain to conceal themselves when surrounding bison as well as to prevent other herds in the area from seeing what was happening. Stalking bison individually, which also required terrain allowing the concealment of hunters (Verbicky-Todd 1984:159) would have been possible in these areas as well.

The buffer zone may define a sort of ecotone or a transition between uplands with game and lowlands with wood, plant foods and water. Dreaver (1980a: chapter 9-14) suggests that may have been the strategy used in his study area in North Blaine County, Montana.

Analysis also indicated that stone ring sites tended to be smaller outside of the bison forage model in the West Block. One possible explanation might be that people working on processing a kill (an activity typically located outside the model or the buffer zone) may have required some

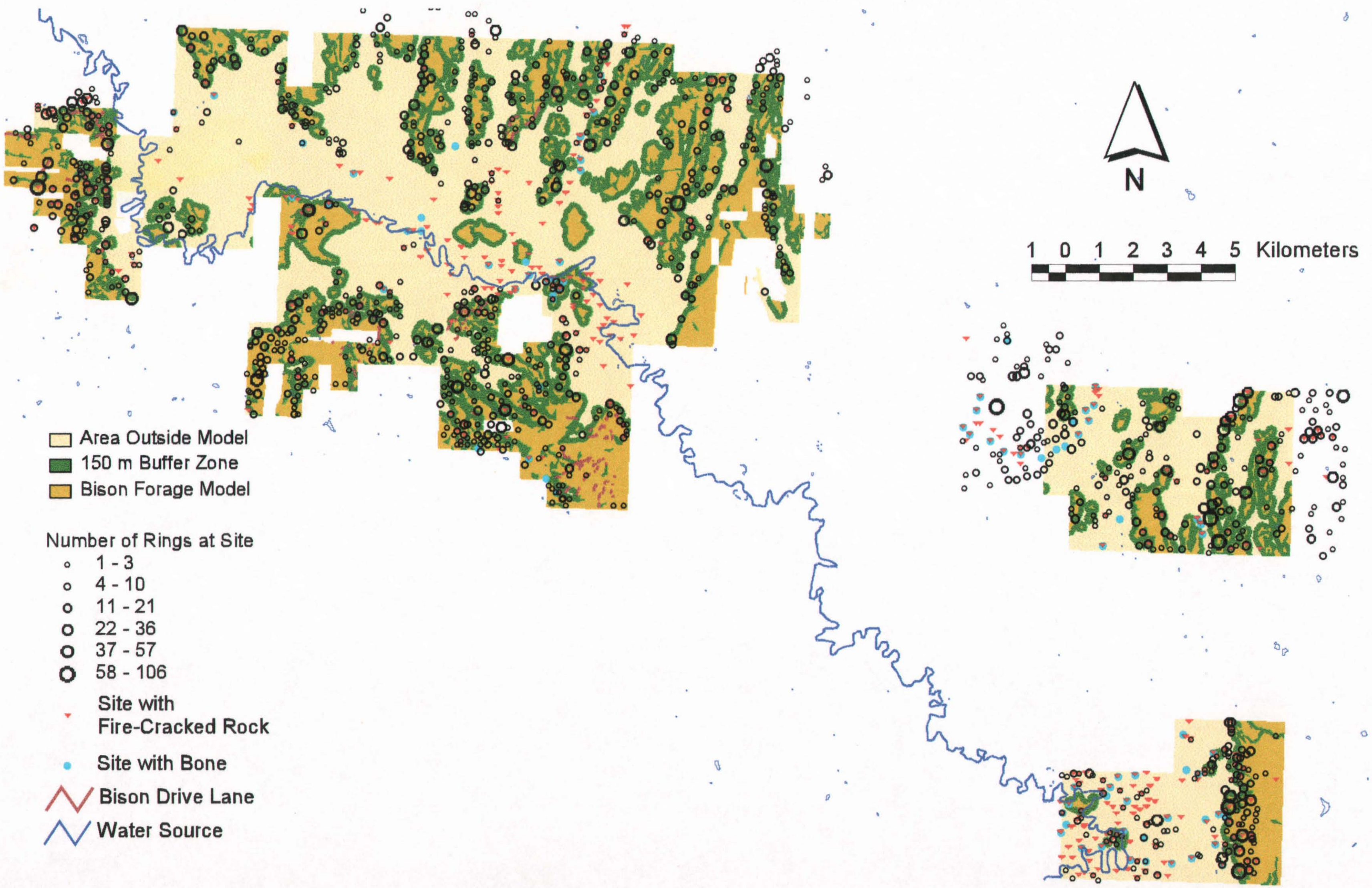

Figure 7.5 Distribution of Sites with Stone Rings, FCR, Bone and Drivelanes Over Bison Forage Model Classes, West Block.

sort of shelter close at hand. This would not have served as the main camp which would have been located in the nearby uplands.

7.2.3 Sites with Fire-cracked Rock

Vegetation

It was only possible to look at fire-cracked rock in the East Block for a comparison with vegetation. The locations of fire-cracked rock strongly follow vegetation patterns. Fire-cracked rock shows a strong positive association with plants which tend to grow on flood plains or along stream banks (classes nine and ten) like greasewood (Tirmenstein 1990) and rose (Crane 1990). This follows the trend associating fire-cracked rock and water sources and emphasizes flowing water sources. Flowing water sources would have been more likely to provide good quality water as other seasonal water sources dried up during the summer and fall. Sites with fire-cracked rock show a strong positive association with vegetation on eroded slopes (class one). This is particularly true for the eastern section of the East Block. An association with slopes reinforces the idea that much of the fire-cracked rock mapped in G.N.P. was produced as the result of processing activities occurring at the base of slopes where bison drives were taking place.

The Bison Forage Model

In the West Block, the association between fire-cracked rock and the bison forage model is not statistically significant. In the East Block fire-cracked rock corresponds with the area outside the model, and is negatively associated with areas inside the model. This seems to be largely a reflection of the water and topographic factors associated with sites with fire-cracked rock. Grassy areas which would have made good bison forage tend not to be near a water source or down the slope from a landscape edge.

8.0 Conclusion

8.1 The Nature of Feature Distributions in the Park

8.1.1 The Relationship Between Sites, Features and Landscape

Patterns of site and feature location are functions of three major factors: geological factors, topographic factors, and floral and faunal resources. Geological processes have altered the archaeological record by removing or burying sites. Areas at the base of the Frenchman River Valley walls as well as larger coulees appear to have been subject to burial due to deposition of eroded materials from the uplands or from slumping or they remained exposed and disintegrated. Sites in general are absent from these areas. In the West Block, drive lanes tend to terminate at the valley edges. It would follow that major kill sites should be located just below these areas, but there is little evidence for their existence. Explanations for this fact may include the possibility that slumping of the valley wall has buried these sites or that exposed bone beds disintegrated before they could be buried.

Another geological consideration has been the effect the presence or absence of stones have had on the visibility of features constructed of stones. More specifically, it was found that in areas of very few stones, stone rings were rare. However, where sufficient stones are available, the proportionate number of stone ring sites do not increase with increasing soil stoniness. This pattern was only observed for the West Block. It is not clear why mapped non-stony areas in the East Block have proportionately as many sites with stone rings as other areas while the West Block shows such a distinct bias. One factor may be that the map of soil stoniness in the East Block was not adequate for the purposes of the research. Mapped stoniness may be representing stones which may not have been of sufficient size for using in stone rings. Adams (1995 Personal

Communication) notes that the east side of the East Block is lacking in stone, resulting in few stone ring sites. This trend is not adequately reflected in the East Block map of soil stoniness.

Topographic factors certainly played a significant role in site location. Distinctive patterns emerged in the distribution of different feature types. The distribution of stone ring sites and sites with fire-cracked rock emerged as two classes of sites which had distinct associations with particular aspects of the landscape. In this case, stone ring sites were predominant in the uplands while fire-cracked rock was often found in valley and coulee bottoms. Although stone ring sites might be expected to be closely related to water, they are not. Fire-cracked rock on the other hand is associated with non-alkali water sources. The separation of these two feature types is again emphasized when vegetation and faunal resources are considered. Stone rings are very strongly associated with areas within and bordering a model of bison forage vegetation while fire-cracked rock has no relationship or is negatively associated.

Taken together, these results can be interpreted in the following way. The distribution of sites and features over the landscape were shaped by a definite allocation of different parts of the landscape for particular uses. Stone rings sites were located primarily in or near areas where bison might be expected to be grazing as well as in areas with topographic relief which would have provided a view of surrounding areas. These factors were apparently more important than proximity to a water source. These results would seem to contradict a model where sites would be located to make optimal use of all surrounding resources. It is suggested here that the different characteristics of these resources may have affected how sites have been located in relation to them. The major resources under consideration here would be water, animal foods, plant foods, and fuel (particularly wood). For anyone who lived in the vicinity of the study areas, the location of water, plant foods and fuel would have been known. Animal foods or game (with a particular emphasis on bison) would have been less predictable than other resources. While bison were known to have been very numerous on the North American continent, they were not always easily located by people who wished to hunt them. In 1773, Cocking reports the difficulties in finding bison to hunt and the resulting hardships (Burpee 1908:113).

What is suggested here is that bison were the least predictable resource people relied on. This lack of predictability may have required arranging camp locations so that opportunities to detect and hunt bison were not missed. It may have been that main camps were located so that hunters would be in a position to see bison if they were present in the grassy areas surrounding the camp. In the West Block, a large proportion of stone ring sites are located in the buffer zone along the edges of the bison forage model (Figure 7.5). This may indicate that camps were not located in the middle of where bison would be grazing but along the edges so as not to disturb them. A location in the grassy uplands would also allow for people to make ready use of bison drives should the need arise. The requirement that camps be located in such a way that they could easily detect if bison were present in an area may have outweighed the advantages of locating camps close to other resources such as water.

Fire-cracked rock shows another distinct pattern. It shows an association with non-alkali water and the bottoms of substantial drainages. While not all fire-cracked rock was the result of processing kills, the majority of fire-cracked rock sites are patterned in such a way that they appear to have been produced via such a process. The bottoms of large drainages are logical places for processing sites if bison are being driven into traps or pounds along the edges of the upland areas. The proximity to water would have been necessary for conducting grease extraction from bones via boiling or for boiling meat. Adding weight to the idea that these fire-cracked rock sites are the result of processing is the fact that bone is often found at the same sites as fire-cracked rock. This is particularly true for the Frenchman River Valley and other large drainages in the East and West Blocks. Although few projectile points were recovered a large number of them are associated with concentrations of fire-cracked rock and bone. This would fit with contention that these concentrations represent processing sites.

Four manos (pestles) and two metates (grinding stones) were found in the Frenchman River Valley. These tools have been commonly interpreted as having been used for processing foods (Frison 1991:84). If this is the case, processing activities in the valley may have included vegetable as well as animal materials.

Lithic scatters are small and numerous in valley and coulee bottoms in the West Block but larger in the upland areas. It may have been that tools made for some immediate use or the sharpening of tools, related to activities at processing sites in the lowlands, produced the numerous but smaller lithic scatters at lower elevations. Larger lithic scatters may have been produced when a number of people associated with a camp were working together to make tools for future use.

8.1.2 Settlement Patterns in the Context of the Seasonal Round

Settlement patterns within the Park would have been subject to the seasonal round undertaken by people who used the area. In order to try and clarify the relationship between settlement patterns and the seasonal round, a comparison of a hypothetical model of the seasonal round with a summary of the statistical analysis of site and feature locations is instructive. The seasonal round summarized is Morgan's (1980) ecological model of bison movements which was considered in section 2.3.1 of this thesis:

Spring: Bison move from the parkland edges to the surrounding mixed prairie. Here the new spring growth provides bison with much needed quality forage.

Summer: The summer range consists of short grass prairie and is located in the southwest ern and south central parts of Saskatchewan. The emergence of blue grama grass in May provides the impetus for bison to move into the summer range, and they may congregate during this movement.

Fall: Bison congregate for the rut which can last anywhere from July to October. After the rut bison disperse and move from their summer range toward their winter range. Lack of water and the decline in the forage quality of curing grasses make the summer range a less desirable place to be for the bison.

Winter: Bison gather in relatively large and sedentary herds in their winter ranges. Winter ranges were the parkland edges and major river valleys.

A comparison of the seasonal round with the summary of analysis in Appendix C indicates a number of possible relationships. The primary variables which are sensitive to seasonality are the availability of water and to some degree elevation and aspect, which provide some information on the shelter available at a site. The large number of habitation (stone ring) sites found in areas far from year-round water sources and their association with seasonally available water sources suggests that G.N.P. was intensively occupied in the spring. As discussed in section 6.3.2 soil profiles indicate intensive seasonal use of the West Block by bison while the ground was still wet (Elena Ponomarenko, Personal Communication 1998). Large numbers of bison may have been gathering in the Park area during the spring to take advantage of the new spring growth of blue grama grass. G.N.P. may also have been used in mid to late summer but probably less intensively as bison would have been spread out over the summer range according to Morgan (1980:152). A preference for north facing slopes observed for sites with stone rings in the West Block suggest a warm season occupation as north facing slopes would not have been subject to the direct summer sun to the same degree as south facing slopes.

Major linear rock alignments in G.N.P. imply bison driving which could have been a major activity carried out in the park during the congregation of bison for the rut in the fall. The large numbers of sites with fire-cracked rock near water and in prominent drainages in both the East and West Blocks were likely to have been at least in part created by bone processing/grease extraction activities, further suggesting major bison kill events. A clustering of habitation sites near the few remaining viable water sources would be a settlement pattern which might be anticipated given current climate regimes . This is moderately true for sites with stone rings in the West Block but the association is not very strong. This is partially explained by the fact that climates in the past appear to have been wetter, with year-round water sources having turned seasonal only more recently. Variables indicating the landscape position of a site appear to have been more important that distance from a water source in terms of settlement pattern and this obscures some information on the seasonality of site location patterns. Sheltered and wooded areas within the Frenchman River Valley may have been used as wintering locations, but other areas of the valley are poorly sheltered with only brush for winter fuel making them less likely wintering spots. From a visual inspection of Figure 6.20, the west side of the West Block seems a likely candidate for a wintering location. A number of large stone ring sites with fire-cracked rock present are located on the west side of the valley bottom where the valley is narrower. The area is currently better treed than other parts of the valley and drive lanes exist on the nearby valley edge. Valley areas have a mean monthly winter temperature which is slightly warmer than upland areas (David Gummer, Personal Communication 1998). The lack of a marked difference between upland and lowland winter temperatures emphasizes the need for wintering locations to have adequate shelter. In sum, the location is protected from prevailing westerly winds, enough wood is available to be used for fuel, and drive lanes on the uplands above could have been used to kill bison during the winter as well as warmer seasons. The location of wintering sites in the Frenchman River Valley appear to require particular elements of topography and resource availability. In the northern portion of the East Block a combination of wooded drainages, springs and nearby grasslands may have made it a wintering spot, and it may have been used year-round.

8.1.3 Some Social Implications

The encampment has often been seen as the centre from which all other activity radiates. This study tends to contradict this notion. Sites become part of a continuum of locations over the landscape. Different activities have distinct relationships to particular elements of the landscape. It is possible that the cultures who produced these sites saw the landscape as divided into areas with both physical and social characteristics. Processing activities related to a bison kill, largely located within valley or large coulee bottoms, would have required significant social organization involving most or all of the community. Encampments, mainly in the uplands, may have had less formal organization where individuals or small groups might have worked on projects of their own such as tool or pottery manufacture.

8.1.4 Comparison With Other Studies

Few analyses of large scale surveys from the areas around G.N.P. attempt to explain the large scale processes which affected land use. Because relationship between site and feature location and the landscape has had only preliminary work done in terms of the areas surrounding

G.N.P., some researchers have felt that surveys were "better suited to hypothesis building than testing" (Davis and Aarberg 1976:50). The arrival of the GIS as a data management and analysis tool should allow for a greater depth of analysis in the future.

Dreaver (1980b) attempted to provide an explanatory model for the results of the surveys in North Blaine and South Philips counties in northern Montana. As was the case for the present analysis, he found a preference for the grassy uplands for many sites while coulees were the preferred location for processing sites (Dreaver 1980b: Chapter 10:18-21). Dreaver interpreted the site location strategies in two ways: sites could be located in places which were close to both upland and lowland resources or major moves were made from one ecological environment to another (1980b: Chapter 10:21-22). Dreaver states that "It appears that the prehistoric inhabitants moved to the type of terrain whose resources they needed and then stayed there until their needs shifted" (1980b:Chapter 10:23). This is to some degree contrary to the findings of the present study. Instead of shifting site locations, the current study shows that sites in different parts of the landscape were characterized by different activities. Processing activities in the Frenchman River Valley and large coulees did not necessitate that camps were moved to these places from the uplands. In general sites appear to have been located to make the best use of both predictable and less predictable resources, depending on the resources required by activities which occurred at the site.

8.2 Future Directions

8.2.1 Major Trends Vs. Minor Trends in the Analysis

The results of the analysis conducted for this thesis emphasize the major trends in the spatial patterns observed for the distribution of sites in the study areas. This appears to have emphasized warmer season activities. It certainly would not mean that the study areas were only occupied by people during this period. Rather, a majority of sites in the study area appear to have been produced during this period. The result is that sites used during this time dominate the analysis and the findings.

Other minor patterns undoubtedly exist. These may reflect local topographic and environmental conditions or they may reflect activities in the Park during different seasons. While it would certainly be possible that people used the Frenchman River Valley as a winter camp spot during the last 3000 years, the evidence for this pattern does not present a large enough trend (in terms of numbers of sites) to have been detected in the overall statistical analysis of site and feature location. Altschul (1990) proposed that sites which did not fit the major trends could be isolated and further analyzed to determine if a sub-pattern of site location existed. As an analysis of the major trends in site and feature location for southwestern Saskatchewan had not yet been conducted, the major thrust of the analysis has been to assess these major trends. A study of minor or sub-trends in site location would certainly be appropriate for further study, especially given the large sample of sites available for analysis.

8.2.2 Future Research

Many possibilities exist for future research, both within G.N.P. and in the Northwestern Plains in general. As mentioned above, an analysis of sites which do not fit the major trends for G.N.P. could reveal further sub-patterns of site and feature location. This would provide a more complete picture of the factors which contributed to site and feature location within the Park. It seems likely that patterns related to season of occupation might emerge.

Ceremonial sites remain a whole additional research area which has yet to be explored. Shifting the focus of analysis would be required in order to try and distinguish social landscapes from the use of the landscape based on subsistence. Methods for assessing patterns of social landscape would have to be developed and evaluated. In addition, into the ceremonial or social significance of different types of sites and features would have to be researched.

On a broader scale, research into site and feature location at other locations on the Northwestern Plains is important. A number of patterns have been identified here but it is not clear if these are area specific or even specific to major landform. There are enough differences between the West and East Blocks at G.N.P. to suggest that each major landform type (like a river valley or rolling plains) may have its own set of considerations when looking at site or feature location.

Understanding of the ecological factors which controlled bison on the Northern Plains needs to be further expanded. The seasonal patterns of aggregation and dispersal of bison had a large impact on the settlement patterns of people in precontact times. Gisiger (1996) has recently been able to map the spatial variability of grass cover in the central Great Plains region using remote sensing images. Information about the onset of and duration of grass greenness was mapped. If this sort of information was correlated with an ecological model of bison movements on the Northern Plains, a sophisticated model of bison movements could be mapped and tested.

References Cited

Adams, Gary.
1976 *Prehistoric Survey of the Lower Red Deer River*. Archaeological Survey of Alberta Occasional Paper No. 3. Alberta Culture Historic Resources Division.

1977 *The Estuary Bison Pound Site in Southwestern Saskatchewan*. Unpublished MA Thesis. University of Saskatchewan, Saskatoon.

1986 Archaeological Reconnaissance of Grasslands National Park 1985. *Saskatchewan Archaeology* 7 : 1-24.

Adams, Gary and Peter Filopoulos
1995 *Grasslands National Park Archaeological Inventory: A Place for All Seasons*. Archaeological Field Services, Department of Canadian Heritage. Professional & Technical Service Centre, Winnipeg, Manitoba.

Adovasio, J.M. and D.R. Pedlar
1997 Monte Verde and the Antiquity of Humankind in the Americas. *Antiquity* 71:573-580.

Allen, Kathleen M. S.
1996 Iroquoian Landscapes: People, Environments, and the GIS Context. In *New Methods, Old Problems Geographic Information Systems in Modern Archaeological Research*. Edited by H. D. G. Machner. pp 198-222. Center for Archaeological Investigations Occasional Paper No. 23. Southern Illinois University at Carbondale, Carbondale, IL.

Altschul, Jeffery H.
1990 Red Flag Models: The Use of Modelling in Management Contexts. In *Interpreting Space: GIS and Archaeology*. Edited by K.M. Allen, S.W. Green and E.B.W. Zubrow. pp. 226-238. Taylor & Francis, London.

Amundson, L.J.
1986 *The Amisk Site: A Multi-Component Campsite in the South-Central Saskatchewan*. Unpublished MA Thesis. University of Saskatchewan, Saskatoon.

Anderson, T.W., Mathewes, R.W., and Schweger, C.E.
1989 Holocene Climatic Trends in Canada With Special Reference to the Hypsithermal Interval. In Chapter 7 of *Quaternary Geology of Canada and Greenland*. R.J. Fulton ed. Geological Survey of Canada, Geology of Canada, no. 1.

Arthur, George W.
1975 *An Introduction to the Ecology of Early Historic Communal Bison Hunting Among the Northern Plains Indians*. National Museum of Man Mercury Series No. 37. Archaeological Survey of Canada, Ottawa.

Atmospheric Environment Service
1982a *Canadian Climate Normals: Temperature and Precipitation, 1951-1980: Prairie Provinces*. Environment Canada.

1982b *Canadian Climate Normals: Wind, 1951-1980*. Volume 5. Environment Canada.

Baena, J., C. Blasco, and V. Recuero.
1995 The Spatial Analysis of Bell Beaker Sites in the Madrid Region of Spain. In *Archaeology and Geographic Information Systems: A European Perspective*. Edited by G. Lock and Z. Stancic. pp 101-116. Taylor and Francis, London.

Barnosky, Cathy W.
1989 Postglacial Vegetation and Climate in the Northwestern Great Plains of Montana. *Quaternary Research* 31:57-73.

Bonnichsen, R.
1991 Clovis Origins. In *Clovis Origins and Adaptations*. Edited by R. Bonnichsen and K.L. Turnmire. pp. 309-329. Center for the Study of the First Americans, Corvallis, Oregon.

Bookbinder, Susan E.J.
1992 *Ecological Characteristics of Grasslands in Grasslands National Park, Saskatchewan*. Unpublished MS Thesis. University of Saskatchewan, Saskatoon.

Brink, Jack
1986 *Dog Days in Southern Alberta*. Archaeological Survey of Alberta Occasional Paper No. 28. Alberta Culture Historic Resources Division.

Brink, Jack and Stuart J. Baldwin
1988 The Highwood River Site: A Pelican Lake Phase Burial from the Alberta Plains. *Canadian Journal of Archaeology* 12:109-135.

Brumley, John H.
1975 *The Cactus Flower Site in Southeastern Alberta: 1972-1974 Excavations*. National Museum of Man Mercury Series No. 46. Archaeological Survey of Canada, Ottawa.

Brumley, John H. and Barry J. Dau
1988 *Historical Resource Investigations Within the Forty Mile Coulee Reservoir*. Archaeological Survey of Alberta Manuscript Series No. 13. Alberta Environment and Alberta Culture and Multiculturalism.

Bryson, Reid A. and Wendland, Wayne M.
1967 Tentative Climatic Patterns for some Late Glacial and Post-Glacial Episodes in Central North America. In *Life, Land and Water*. M.J. Mayer-Oakes ed. Winnipeg: University of Manitoba Press.

Buchner, A.P.
1980 *Cultural Responses to Altithermal (Atlantic) Climate Along the Eastern Margins of the North American Grasslands 5500 to 3000 BC.* National Museum of Man Mercury Series No. 97. Archaeological Survey of Canada, Ottawa.

Burpee, L.J. (editor)
1907 York Factory to the Blackfoot Country: The Journal of Anthony Hendry [sic], 1754-55. *Proceeding and Transactions of the Royal Society of Canada* 3(1):307-359.

1908 An Adventurer from Hudson Bay: Journal of Mathew Cocking, From York Factory to the Blackfoot Country, 1772-73. *Proceeding and Transactions of the Royal Society of Canada*. Third Series, 2(3):89-121.

Butzer, Karl W.
1982 *Archaeology as Human Ecology: Method and Theory for a Contextual Approach.* Cambridge University Press, Cambridge.

Carmichael, David L.
1990 GIS Predictive Modelling of Prehistoric Site Distributions in Central Montana. In *Interpreting Space: GIS and Archaeology.* Edited by K.M. Allen, S.W. Green and E.B.W. Zubrow. pp. 216-225. Taylor & Francis, London.

Carrara, Alberto, Gabriele Bitelli, and Roberto Carla
1997 Comparison of Techniques for Generating Digital Terrain Models from Contour Lines. *International Journal of Geographical Information Science* 11(5):451-473.

Christiansen, E.A., and Sauer, E.K.
1988 Age of the Frenchman Valley and Associated Drift South of the Cypress Hills, Saskatchewan, Canada. *Canadian Journal of Earth Sciences* 25:1703-1708.

Corbeil, Marcel
1995 *The Archaeology and Taphonomy of the Hero Eden Site, Southwestern Saskatoon.* Unpublished MA Thesis. University of Saskatchewan, Saskatoon.

Crane, M.F.
1990 Rosa acicularis. In *The Fire Effects Information System [Data Base].* Compiled by William C. Fischer. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory, Missoula, Montana. http://www.fs.fed.us/database/feis/

Dalla Bona, Luke
1993 *A Predictive Model of Prehistoric Activity Location for the Souris River, Saskatchewan.* Unpublished MA Thesis. University of Manitoba, Winnipeg.

Dalla Bona, Luke, and Linda Larcombe
1996 Modeling Prehistoric Land Use in Northern Ontario. In *New Methods, Old Problems Geographic Information Systems in Modern Archaeological Research*. Edited by H. D. G. Machner. pp. 252-274. Center for Archaeological Investigations Occasional Paper No. 23. Southern Illinois University at Carbondale, Carbondale, IL.

Davis, Leslie B.
1975 *The Prehistory of the Whitewater-Frenchman Creek/Milk River Locality, Northeastern Montana: An Introduction*. Report Submitted to the Whitewater School District #20AA and the Bureau of Land Management, Malta District and Billings State Office.

Davis, Leslie B. and Stephen A. Aaberg
1976 *Reserved Natural and Cultural Heritage Resources in the Brazil/Little Beaver Creeks Bentonite Mining Claim Area, Southwest Valley County, Montana: Impact Intervention*. Report to Ecological Consulting Services, Inc., as Agent for Aurora Metal Company, by Montana State University, Bozeman.

Davis, Leslie B. and John W. Fisher, Jr.
1988 Avonlea Predation on Wintering Plains Pronghorns. In *Avonlea Yesterday and Today: Archaeology and Prehistory*. Leslie B. Davis ed. pp. 101-118. Saskatchewan Archaeological Society, Saskatoon.

Dirschl, Herman J.
1961 *Food Habits and Range of the Pronghorn Antelope in Saskatchewan*. Unpublished Master's Thesis. University of Saskatchewan, Saskatoon.

Dreaver, Ken
1980a *Archaeological Site Distribution in North Blaine County, Montana; Report of a Class II Cultural Resources Inventory in Blaine County, Montana*. Report to the Bureau of Land Management, Denver Federal Center, Denver, by Professional Analysts, Eugene, Oregon.

1980b *Archaeological Site Distribution in South Philips County, Montana; Report of a Class II Cultural Resources Inventory with Supporting Data from a Similar Inventory in Blaine County, Montana*. Report to the Bureau of Land Management, Denver Federal Center, Denver, by Professional Analysts, Eugene, Oregon.

Dreaver, Ken and J. Morter
1981 *Site Distribution in the Fresno and Nelson Reservoir Areas, North Central Montana*. Report to the Bureau of Reclamation, Billings Montana by Professional Analysts, Eugene, Oregon.

Dyck, Ian
1977 *The Harder Site: A Middle Period Bison Hunter's Campsite in the Northern Great Plains*. National Museum of Man Mercury Series No. 67. Archaeological Survey of Canada, Ottawa.

1983 The Prehistory of Southern Saskatchewan. In *Tracking Ancient Hunters: Prehistoric Archaeology in Saskatchewan*. Henry T. Epp and Ian Dyck eds. Regina: Saskatchewan Archaeological Society.

Dyck, Ian and Richard E. Morlan
1995 *The Sjovold Site: A River Crossing Campsite in the Northern Plains*. Archaeological Survey of Canada Mercury Series Paper 151, Canadian Museum of Civilization.

Ebdon, David
1985 *Statistics in Geography*. Second Edition. Basil Blackwell Ltd, Oxford.

Foor, Thomas Allyn
1982 *Cultural Continuity on the Northwestern Great Plains – 1300 B.C. to A.D. 200, The Pelican Lake Culture*. Unpublished Ph.D. Thesis. University of California, Santa Barbara.

Frison, George
1970 The Kobold Site, 24BH406: A Post-Altithermal Record of Buffalo-Jumping for the Northwestern Plains. *Plains Anthropologist* 15(47):1-35.

1971 The Buffalo Pound in North-Western Plains Prehistory: Site 48 CA 302, Wyoming. *American Antiquity* 36(1):77-91.

1988 Avonlea and Contemporaries in Wyoming. In *Avonlea Yesterday and Today: Archaeology and Prehistory*. Leslie B. Davis ed. pp. 155-170. Saskatchewan Archaeological Society, Saskatoon.

1991 *Prehistoric Hunters of the High Plains*. Second Edition. Academic Press, New York.

Frison, George C. and Dennis J. Stanford
1982 *The Agate Basin Site: A Record of the Paleoindian Occupation of the Northwestern High Plains*. Academic Press, New York.

Frison, George C. and Lawrence C. Todd (editors)
1987 *The Agate Basin Site: A Record of the Paleoindian Occupation of the Northwestern High Plains*. Academic Press, New York.

Frison, George C., Michael Wilson and Diane J. Wilson
1976 Fossil Bison and Artifacts from an Early Altithermal Period Arroyo Trap in Wyoming. *American Antiquity* 41(1):28-57.

Gaffney, Vincent, and Zoran Stancic
1991 *GIS Approaches to Regional Analysis: A Case Study of the Island of Hvar*. Znanstveni Institut Filozofske Fakultete, Ljubljana.

Gaffney, Vincent, and Martijn P. van Leusen
1995 Postscript - GIS, Environmental Determinism and Archaeology: a Parallel Text. In *Archaeology and Geographic Information Systems: A European Perspective*. Edited by G. Lock and Z. Stancic. pp 367-382. Taylor & Francis, London.

Gaffney, Vincent, Zoran Stancic, and H. Watson

1995 The Impact of GIS on Archaeology: a Personal Perspective. In *Archaeology and Geographic Information Systems: A European Perspective*. Edited by G. Lock and Z. Stancic. pp 211-230. Taylor & Francis, London.

1996 Moving from Catchments to Cognition: Tentative Steps Toward a Larger Archaeological Context for GIS. In *Anthropology, Space, and Geographic Information Systems*. Edited by M.S. Aldenderfer and H.D.G. Maschner. pp. 132-154. Oxford University Press, Oxford.

Gillings, Mark

1997 Not Drowning but Waving? The Tisza Flood-Plain Revisited. In *Archaeological Applications of GIS: Proceedings of Colloquium II, UISPP XIIIth Congress, Forli, Italy, September 1996*. Edited by I. a. N. Johnson, M. Sydney University Archaeological Methods Series 5.

Gisiger, Anne

1996 *A Spatial Analysis of Regional Human Adaptation Patterns Using Continental Scale Data*. Unpublished MA Thesis. University of Arkansas, Arkansas.

Gordon, Bryan H. C.

1979 *Of Men and Herds in Canadian Plains Prehistory*. National Museum of Man Mercury Series No. 84. Archaeological Survey of Canada, Ottawa.

Graham, Mary Ann; Wilson, Michael C. and Graham, Russell W.

1987 Paleoenvironments and Mammalian Faunas of Montana, Southern Alberta, and Southern Saskatchewan. In *Late Quaternary Mammalian Biogeography and Environments of the Great Plains and Prairies*. R. Graham, H.A. Semken Jr. and M.A. Graham eds. Illinois State Museum Scientific Papers, Vol. XXII.

Graspointner, Andreas

1980 *Archaeology and Ethno-History of the Milk River in Southern Alberta*. Western Publishers, Calgary.

Haig, Bruce (editor)

1990 *A Look at Peter Fidler's Journal: Journal of a Journey Over Land from Buckingham House to the Rocky Mountains in 1792 &3*. Historic Research Centre, Lethbridge, Alberta.

Harrington, C.R.

1978 Quaternary Vertebrate Faunas of Canada and Alaska and their Suggested Chronological Sequence. *Syllogeus* 15. National Museums of Canada, Ottawa.

Harris, Trevor M., and Gary R. Lock.

1995 Toward an Evaluation of GIS in European archaeology: The Past, Present and Future of Theory and Applications. In *Archaeology and Geographic Information Systems: A European Perspective*. Edited by G. Lock and Z. Stancic. pp 349-366. Taylor & Francis, London.

1996 Danebury Revisted: An English Iron Age Hillfort in a Digital Landscape. In. *Anthropology, Space, and Geographic Information Systems*. Edited by M.S. Aldenderfer and H.D.G. Maschner. pp. 175-189. Oxford University Press, Oxford.

Hasenstab, Robert J.
1996 Settlement As Adaptation: Variability in Iroquois Village Site Selection As Inferred Through GIS. In *New Methods, Old Problems Geographic Information Systems in Modern Archaeological Research*. Edited by H. D. G. Machner. pp 223-241. Center for Archaeological Investigations Occasional Paper No. 23. Southern Illinois University at Carbondale, Carbondale, IL.

Hasenstab, Robert J. and Benjamin Resnick
1990 GIS in Historical Predictive Modelling: The Fort Drum Project. In *Interpreting Space: GIS and Archaeology*. Edited by K.M. Allen, S.W. Green and E.B.W. Zubrow. pp. 284-306. Taylor & Francis, London.

Haskell, Brian J.; D.R. Engstrom and S.C. Fritz.
1996 Late Quaternary Paleohydrology in the North American Great Plains Inferred from the Geochemistry of Endogenic Carbonate and Fossil Ostracodes from Devils Lake, North Dakota, USA. *Palaeogeography, Palaeoclimatology, Palaeoecology* 124:179-193.

Haynes, C.V.
1982 Were Clovis Progenitors in Beringia? In *Paleoecology of Beringia*. Edited by D.M. Hopkins, J.V. Matthews Jr., C.E. Schweger, and S.B. Young. pp. 383-398. Academic Press, New York.

1993 Clovis-Folsom Geochronology and Climate Change. In *From Kostienki to Clovis: Upper Paleolithic - Paleo-Indian Adaptations*. Edited by Olga Soffer and N.D. Praslov. Plenum Press, New York.

Hjermsted, Benjamin E.
1996 *The Fitzgerald Site: A Besant Pound and Processing Area on the Northern Plains*. Unpublished MA Thesis. University of Saskatchewan, Saskatoon.

Klassen, Rudy.W.
1989 Quaternary Geology of the Southern Interior Canadian Plains. In Chapter 2 of *Quaternary Geology of Canada and Greenland*. R.J. Fulton ed. Geological Survey of Canada, Geology of Canada, no. 1.

1992 Nature, Origin, and Age Relationships of Landscape Complexes in Southwestern Saskatchewan. *Geographie Physique et Quaternaire* 46(3):361-388.

1994 Late Wisconsin and Holocene History of Southwestern Saskatchewan. *Canadian Journal of Earth Sciences* 31:1822-1837.

Kvamme, Kenneth L.

1989 Geographic Information Systems in Regional Archaeological Research and Data Management. In *Archaeological Method and Theory* Volume 1. Edited by M. Schiffer. The University of Arizona Press, Tuscon.

1992 A predictive Site Location Model on the High Plains: An Example with an Independent Test. *Plains Anthropologist* 37:19-40.

1995 A View From Across the Water: the North American Experience in Archaeological GIS. In *Archaeology and Geographic Information Systems: A European Perspective*. Edited by G. Lock and Z. Stancic. pp 1-14. Taylor & Francis, London.

Larpenteur, Charles

1989 *Forty Years a Fur Trader on the Upper Missouri: The Personal Narrative of Charles Larpenteur 1833-1872*. University of Nebraska Press, Lincon.

Leighton, Anna

n.d. *Plants Used by Native Peoples of the Study Area.* Report Prepared for Archaeology Department, Canadian Heritage, Winnipeg.

Lillesand, Thomas M. and Ralph W. Kiefer

1994 *Remote Sensing and Image Interpretation.* Second Edition. John Wiley & Sons, Inc., New York.

Limp, W. Fredrick

1997 Developing Methodologies in the Analysis of Spatially Referenced Data and their Impacts on Archaeological Method and Theory. In *Archaeological Applications of GIS: Proceedings of Colloquium II, UISPP XIIIth Congress, Forli, Italy, September 1996.* Edited by I. a. N. Johnson, M. Sydney University Archaeological Methods Series 5.

Loveridge, D.M. and Barry Potyondi

1977 *From Wood Mountain to the Whitemud: An Historical Survey of the Grasslands National Park Area*. National Historic Parks and Sites Branch, Manuscript Report Number 237, Parks Canada and the Department of Indian and Northern Affairs.

Magne, Martin and Contributors to the Saskatchewan-Alberta Dialogue

1987 Distributions of Native Groups in Western Canada, A.D. 1700 to A.D. 1850. In *Archaeological in Alberta 1986*. Edited by Martin Magne, pp. 220-232. Archaeological Survey of Alberta Occasional Paper No. 31. Alberta Culture Historic Resources Division.

Malainey, Mary E.

1991 *Internal and External Relationships of Saskatchewan Plains Pottery Assemblages: Circa A.D. 1300 to Contact.* Unpublished MA Thesis. University of Saskatchewan, Saskatoon.

Martlew, Rodger
1997 Archaeological Landscapes and Environmental Reconstruction in the Yorkshire Dales, UK: GIS Models and Environmental Determinism. In *Archaeological Applications of GIS: Proceedings of Colloquium II, UISPP XIIIth Congress, Forli, Italy, September 1996*. Edited by I. a. N. Johnson, M. Sydney University Archaeological Methods Series 5.

Maschner, Herbert D.G.
1996 The Politics of Settlement Choice on the Northwest Coast: Cognition, GIS, and Coastal Landscapes. In *Anthropology, Space, and Geographic Information Systems*. Edited by M.S. Aldenderfer and H.D.G. Maschner. pp. 175-189. Oxford University Press, Oxford.

Milne, Laurie Ann
1988 The Larson Site (DlOn-3) and the Avonlea Phase in Southwestern Alberta. In *Avonlea Yesterday and Today: Archaeology and Prehistory*. Leslie B. Davis ed. pp. 43-66. Saskatchewan Archaeological Society, Saskatoon.

McGlade, James
1997 GIS and Integrated Archaeological Knowledge Systems. In *Archaeological Applications of GIS: Proceedings of Colloquium II, UISPP XIIIth Congress, Forli, Italy, September 1996*. Edited by I. a. N. Johnson, M. Sydney University Archaeological Methods Series 5.

McMillan, Alan D.
1995 *Native Peoples and Cultures of Canada: An Anthropological Overview*. Second Edition. Douglas & McIntyre, Vancouver and Toronto.

McTavish, P.
1997 *Grasslands National Park Mapping Request*. Report Prepared for Grasslands National Park, Val Marie, Saskatchewan. Publication No. I4900-7-C-97. Saskatchewan Research Council, Saskatoon.

Meltzer, D.J.
1993 Is there a Clovis Adaptation? In *From Kostienki to Clovis: Upper Paleolithic - Paleo-Indian Adaptations*. Edited by Olga Soffer and N.D. Praslov. pp. 293-309. Plenum Press, New York.

Millar, J.F.V.
1981a Mortuary Practices of the Oxbow Complex. *Canadian Journal of Archaeology* 5:103-118.

1981b The Oxbow Complex: 1980 Perspectives. *Canadian Journal of Archaeology* 5:155-160.

Morgan, Grace R.
1980 Bison Movement Patterns on the Canadian Plains: An Ecological Analysis. *Plains Anthropologist* 25:143-60.

Morlan, Richard E.
1993 A Compilation and Evaluation of Radiocarbon Dates in Saskatchewan. *Saskatchewan Archaeology* 13:3-84.

Peacock, Sandra Leslie
1992 *Piikáni Ethnobotany: Traditional Plant Knowledge of the Piikáni People of the Northwestern Plains*. Unpublished MA Thesis. University of Calgary, Calgary.

Peden, Donald G.
1976 Botanical Composition of Bison Diets on Shortgrass Plains. *The American Midland Naturalist* 96(1):225-229.

Pickering, Michael.
1994 The Physical Landscape as a Social Landscape: A Garawa Example. *Archaeology of Oceania* 29:149-161.

Pligram, Tom.
1987 *Predicting Archaeological Sites from Environmental Variables, A Mathematical Model for the Sierra Nevada Foothills, California*. BAR International Series 320. Oxford.

Ramsay, Charles L.
1993 *The Redtail Site: A McKean Habitation in South Central Saskatchewan*. Unpublished M.A. Thesis. University of Saskatchewan, Saskatoon.

Ray, Arthur J.
1974 *Indians in the Fur Trade: Their Role as Trappers, Hunters, and Middlemen in the Lands Southwest of Hudson Bay*. University of Toronto Press, Toronto.

Reeves, B.O.K.
1973 The Concept of the Altithermal Cultural Hiatus in Northern Plains Prehistory. *American Anthropologist* 75(5):1221-1253.

1983 *Culture Change in the Northern Plains: 1000 B.C. – A.D. 1000*. Archaeological Survey of Alberta Occasional Paper No. 20. Alberta Culture Historic Resources Division.

Reher, Charles A. and George C. Frison
1980 The Vore Site, 48CK302, a Stratified Buffalo Jump in the Wyoming Black Hills. *Plains Anthropologist Memoir* No. 16.

Ritchie, J.C.
1976 The Late-Quaternary Vegetational History of the Western Interior of Canada. *Canadian Journal of Botany* 54:1793-1818.

Ruggles, Clive N.L. and David J. Medyckyj-Scott
1996 Site Location, Landscape Visibility, and Symbolic Astronomy: A Scottish Case Study. In *New Methods, Old Problems Geographic Information Systems in Modern Archaeological Research*. Edited by H. D. G. Machner. pp 127-146. Center for Archaeological Investigations Occasional Paper No. 23. Southern Illinois University at Carbondale, Carbondale, IL.

Russell, Dale R.
1991 *Eighteenth-Century Western Cree and their Neighbours*. Archaeological Survey of Canada Mercury Series Paper 143, Canadian Museum of Civilization.

Sauchyn, David J.
1990 A Reconstruction of Holocene Geomorphology and Climate, Western Cypress Hills, Alberta and Saskatchewan. *Canadian Journal of Earth Sciences* 27:1504-1510.

Sauchyn, Mary A. and Sauchyn, David J.
1991 A Continuous Record of Pollen from Harris Lake, Southwestern Saskatchewan, Canada. *Palaeogeography, Palaeoclimatology, Palaeoecology* 88:13-23.

Smith, Brian J. and Ernest G. Walker
1988 Evidence for Diverse Subsistence Strategies in an Avonlea Component. In *Avonlea Yesterday and Today: Archaeology and Prehistory*. Leslie B. Davis ed. pp. 81-88. Saskatchewan Archaeological Society, Saskatoon.

Stanford, D.
1991 Clovis Origins and Adaptations: An Introductory Perspective. In *Clovis Origins and Adaptations*. Edited by R. Bonnichsen and K.L. Turnmire. pp. 1-13. Center for the Study of the First Americans, Corvallis, Oregon.

Tesky, Julie L.
1995 Bison bison. In *The Fire Effects Information System [Data Base]*. Compiled by William C. Fischer. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory, Missoula, Montana. http://www.fs.fed.us/database/feis/

Thomas, David Hurst
1986 *Refiguring Anthropology; First Principles of Probability & Statistics*. Waveland Press, Prospect Heights, Illinois.

Tirmenstein, D.A.
1987 Bouteloua gracilis. In *The Fire Effects Information System [Data Base]*. Compiled by William C. Fischer. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory, Missoula, Montana. http://www.fs.fed.us/database/feis/

1990 Sarcobatus vermiculatus. In *The Fire Effects Information System [Data Base]*. Compiled by William C. Fischer. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Intermountain Fire Sciences Laboratory, Missoula, Montana. http://www.fs.fed.us/database/feis/

Trigger, Bruce G.
1989 *A History of Archaeological Thought*. Cambridge University Press, Cambridge.

Valero-Garcés, Blas L.; K.R. Laird; S.C. Fritz; K. Kelts; E. Ito and E.C. Grimm
1997 Holocene Climate in the Northern Great Plains Inferred from Sediment Stratigraphy, Stable Isotopes, Carbonate Geochemistry, Diatoms, and Pollen at Moon Lake, North Dakota. *Quaternary Research* 48:359-369.

Vance, R.E.; Mathewes, R.W. and Clague, J.J.
1992 7000 Year Record of Lake-Level Change on the Northern Great Plains: A High Resolution Proxy of Past Climate. *Geology* 20:879-882.

Verbicky-Todd, Eleanor
1984 *Communal Buffalo Hunting Among the Plains Indians*. Archaeological Survey of Alberta Occasional Paper No. 24. Alberta Culture Historic Resources Division.

Vickers, J. Roderick
1986 *Alberta Plains Prehistory: A Review*. Archaeological Survey of Alberta Occasional Paper No. 27. Alberta Culture Historic Resources Division.

1994 Cultures of the Northwestern Plains: From the Boreal Forest Edge to Milk River. In *Plains Indians, A.D. 500-1500: The Archaeological Past of Historic Groups*. Edited by Karl H. Schlesier. University of Oklahoma Press, Norman and London.

Vreeken, Willem J.
1994 A Holocene Soil-Geomorphic Record for the Ham Site Near Frontier, Southwestern Saskatchewan. *Canadian Journal of Earth Sciences* 31:532-543.

Walde, Dale A.
1994 *The Mortlach Phase*. Unpublished PhD Thesis. University of Calgary, Calgary.

Walker, Ernest G.
1982 The Bracken Cairn Site. *Saskatchewan Archaeology* 3:8-35.

1992 *The Gowen Sites: Cultural Responses to Climatic Warming on the Northern Plains (7500 – 500 B.P.)*. Archaeological Survey of Canada Mercury Series Paper 145, Canadian Museum of Civilization.

Wandsnider, L. and E. Camilli
1992 The Character of Surface Archaeological Deposits and Its Influence on Survey Accuracy. *Journal of Field Archaeology* 19(2):169-187.

Warren, Robert E.
1990 Predictive Modelling of Archaeological Site Location: A Case Study in the Midwest. In *Interpreting Space: GIS and Archaeology*. Edited by K.M. Allen, S.W. Green and E.B.W. Zubrow. pp. 201-215. Taylor & Francis, London.

Weimer, Monica Bargielski.
1995 Predictive Modeling and Cultural Resource Management: An Alternative View from the Plains Periphery. In *Beyond Subsistence, Plains Archaeology and the Postprocessual Critique*. Edited by P. Duke and M. C. Wilson. Pp 90-112. The University of Alabama Press, Tuscaloosa.

Wendland, Wayne M.
1978 Holocene Man in North America: The Ecological Setting and Climatic Background. *Plains Anthropologist* 23:273-287.

Wheatley, David.
1993 Going Over Old Ground: GIS, Archaeological Theory and the Act of Perception. In *Computing the Past, Computer Applications and Quantitative Methods in Archaeology, CAA92*. Edited by J. Andresen, T. Madsen and S. Irvin. Aarhus University Press, Aarhus.

1995 Cumulative Viewshed Analysis: A GIS-Based Method for Investigating Intervisibility, and its Archaeological Application. In *Archaeology and Geographic Information Systems: A European Perspective*. Edited by G. Lock and Z. Stancic. pp 171-186. Taylor and Francis, London.

Wright, J. V.
1995 *A History of the Native People of Canada: Volume I (10,000 – 1,000 B.C.)*. Archaeological Survey of Canada Mercury Series Paper 152, Canadian Museum of Civilization.

Zubrow, Ezra B.W.
1994 Knowledge Representation and Archaeology: A Cognitive Example Using GIS. In *The Ancient Mind: Elements of Cognitive Archaeology*. Edited by Colin Renfrew and Ezra B.W. Zubrow. Cambridge University Press, Cambridge.

Appendix A: Single-Sample Chi Square Tests

Table A1. Sites Overall Compared with Surficial Geology, West Block.

Class	*Geology*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Associations*
1	Glacial	86.19	612	480.1	36.20	+
5	Alluvial	35.92	174	200.1	3.40	-
6	Colluvial	126.88	601	706.8	15.80	-
Totals		248.99	1387	1387.0	55.40	
degrees of freedom: 2		**sig. 0.05:**	5.99			

Table A2. Sites Overall Compared with Surficial Geology, East Block.

Class	*Geology*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Glacial	65.88	444	458.4	0.45	
3	Bedrock	66.30	463	461.4	0.01	
5	Alluvial	36.57	263	254.4	0.29	
6	Colluvial	23.96	171	166.7	0.11	
Totals		192.71	1341	1340.9	0.86	
degrees of freedom: 3		**sig. 0.05:**	7.82	**Not Significant**		

Table A3. Sites Overall Compared with Classes of Erosion, West Block.

Class	*Degree*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Unaffected	32.23	183	171.2	0.81	
2	Weak	71.22	464	378.3	19.41	+
3	Moderate	32.03	184	170.1	1.14	
4	Strong	36.17	145	192.1	11.55	-
5	Severe	21.67	69	115.1	18.46	-
6	Very Severe	6.82	18	36.2	9.15	-
Totals		200.14	1063	1063.0	60.52	
degrees of freedom: 5		**sig. 0.05:**	11.07			

Table A4. Sites Overall Compared with Classes of Erosion, East Block.

Class	*Degree*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Unaffected	15.24	95	105.0	0.95	
2	Weak	27.2	196	187.3	0.40	
3	Moderate	26.68	192	183.7	0.38	
4	Strong	17.67	118	121.7	0.11	
5	Severe	4.57	27	31.5	0.64	
6	Very Severe	0.7	6	4.8	0.30	
Totals		92.06	634	634.0	2.78	
degrees of freedom: 5		**sig. 0.05:**	11.07	**Not Significant**		

Table A5. Sites with Stone Rings Compared with Classes of Soil Stoniness, West Block.

Class	*% Surface/Stones*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	32.50	20	126.2	89.37	-
5	none - 0.1	19.69	32	76.5	25.89	-
10	0.01 - 0.01	48.47	179	188.3	0.46	
15	0.01 - 3	42.03	207	163.3	11.69	+
20	0.1 - 3	24.05	136	93.4	19.43	+
25	0.1 - 15	23.09	119	89.7	9.57	+
30	3 - 15	23.64	122	91.8	9.94	+
35	3 - 50	9.36	56	36.4	10.55	+
40	15 - 50	6.90	16	26.8	4.35	+
45	15 - >50	0.41	7	1.6	18.23	+
Totals		230.14	894	894.0	199.48	
degrees of freedom: 10		**sig. 0.05:**	18.31			

Table A6. Sites with Stone Rings Compared with Classes of Soil Stoniness, East Block.

Class	*% Surface/Stones*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	28.21	123	98.2	6.26	+
5	none - 0.1	24.00	67	83.5	3.26	-
10	0.01 - 0.01	12.44	41	43.3	0.12	
15	0.01 - 3	12.67	21	44.1	12.10	-
20	0.1 - 3	6.39	23	22.2	0.03	
25	0.1 - 15	7.52	25	26.2	0.05	
30	3 - 15	5.79	32	20.1	7.05	+
35	3 - 50	0.78	5	2.7	1.96	+
40, 45	15 - >50	0.78	6	2.7	4.03	+
Totals		98.58	343	343.0	34.86	
degrees of freedom: 9		**sig. 0.05:**	16.92			

Table A7. Sites Overall Compared with Elevation Classes, West Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2450 to 2505	6.79	59	38.1	11.46	+
2	2506 to 2569	31.89	146	179.0	6.08	-
3	2570 to 2657	58.44	257	328.0	15.37	-
4	2658 to 2716	35.06	203	196.8	0.20	
5	2717 to 2829	65.37	384	366.9	0.80	
6	2830 to 2897	24.52	167	137.1	6.52	+
7	2898 to 3043	32.43	205	182.0	2.91	+
8	3044 to 3304	12.55	78	70.4	0.82	
Totals		267.05	1499	1498.3	44.16	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A8. Sites with Stone Rings Compared with Elevation Classes, West Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2450 to 2505	3.46	14	16.1	0.27	
2	2506 to 2569	10.50	28	48.9	8.93	-
3	2570 to 2657	44.53	131	207.2	28.02	-
4	2658 to 2716	32.03	148	149.1	0.01	
5	2717 to 2829	59.79	310	278.3	3.61	+
6	2830 to 2897	22.27	127	103.6	5.29	+
7	2898 to 3043	29.78	176	138.6	10.09	+
8	3044 to 3304	12.51	66	58.2	1.05	
Totals		214.87	1000	1000.0	57.27	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A9. Sites with Lithic Scatters Compared with Elevation Classes, West Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2450 to 2505	6.79	54	21.7	48.07	+
2	2506 to 2569	31.89	137	102.1	11.93	+
3	2570 to 2657	58.44	170	187.1	1.55	
4	2658 to 2716	35.06	100	112.2	1.33	
5	2717 to 2829	65.37	175	209.3	5.62	-
6	2830 to 2897	24.52	88	78.5	1.15	
7	2898 to 3043	32.43	95	103.8	0.75	
8	3044 to 3304	12.55	36	40.2	0.44	
Totals		267.05	855	854.9	70.84	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A10. Sites with FCR Compared with Elevation Classes, West Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2450 to 2505	6.79	46	10.1	127.60	+
2	2506 to 2569	31.89	102	47.3	63.26	+
3	2570 to 2657	58.44	88	86.7	0.02	
4	2658 to 2716	35.06	27	52.0	12.02	-
5	2717 to 2829	65.37	42	96.9	31.10	-
6	2830 to 2897	24.52	19	36.4	8.32	-
7	2898 to 3043	32.43	52	48.1	0.32	
8	3044 to 3304	12.55	20	18.6	0.11	
Totals		267.05	396	396.1	242.75	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A11. Sites with Hearths Compared with Elevation Classes, West Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2450 to 2505	6.79	6	5.1	0.16	
2	2506 to 2569	31.89	20	23.9	0.64	
3	2570 to 2657	58.44	29	43.8	5.00	-
4	2658 to 2716	35.06	22	26.3	0.70	
5	2717 to 2829	65.37	58	49.0	1.65	
6	2830 to 2897	24.52	22	18.4	0.70	
7	2898 to 3043	32.43	25	24.3	0.02	
8	3044 to 3304	12.55	18	9.4	7.87	+
Totals		267.05	200	200.2	16.74	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A12. Sites Overall Compared with Elevation Classes, East Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2539 to 2614	19.50	116	133.7	2.34	-
2	2615 to 2686	52.32	325	358.7	3.17	-
3	2687 to 2779	46.09	325	316.0	0.26	
4	2780 to 2900	50.02	347	342.9	0.05	
5	2901 to 2963	12.27	82	84.1	0.05	
6	2964 to 3046	9.21	82	63.1	5.66	+
7	3047 to 3136	5.40	36	37.0	0.03	
8	3137 to 3296	5.74	62	39.4	12.96	+
Totals		200.55	1375	1374.9	24.52	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A13. Sites Stone Rings Compared with Elevation Classes, East Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2539 to 2614	19.50	30	68.7	21.80	-
2	2615 to 2686	52.32	136	184.2	12.61	-
3	2687 to 2779	46.09	187	162.3	3.76	+
4	2780 to 2900	50.02	195	176.1	2.03	
5	2901 to 2963	12.27	44	43.2	0.01	
6	2964 to 3046	9.21	54	32.4	14.31	+
7	3047 to 3136	5.40	17	19.0	0.21	
8	3137 to 3296	5.74	43	20.2	25.73	+
Totals		200.55	706	706.1	80.46	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A14. Sites with Lithic Scatters Compared with Elevation Classes, East Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2539 to 2614	19.50	87	82.3	0.27	
2	2615 to 2686	52.32	226	226.7	0.00	
3	2687 to 2779	46.09	203	199.7	0.05	
4	2780 to 2900	50.02	183	216.7	5.24	-
5	2901 to 2963	12.27	53	53.2	0.00	
6	2964 to 3046	9.21	41	39.9	0.03	
7	3047 to 3136	5.40	26	23.4	0.29	
8	3137 to 3296	5.74	50	24.9	25.30	+
Totals		200.55	869	866.8	31.18	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A15. Sites with FCR Compared with Elevation Classes, East Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2539 to 2614	19.50	78	59.0	6.12	+
2	2615 to 2686	52.32	143	158.4	1.50	
3	2687 to 2779	46.09	133	139.5	0.30	
4	2780 to 2900	50.02	131	151.4	2.75	
5	2901 to 2963	12.27	35	37.1	0.12	
6	2964 to 3046	9.21	29	27.9	0.04	
7	3047 to 3136	5.40	23	16.3	2.75	+
8	3137 to 3296	5.74	35	17.4	17.80	+
Totals		200.55	607	607.0	31.38	
degrees of freedom: 7			**sig. 0.05:**	14.07		

Table A16. Sites with Hearths Compared with Elevation Classes, East Block.

Class	*Elevation (ft)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	2539 to 2614	19.50	15	12.5	0.50	
2	2615 to 2686	52.32	22	33.7	4.06	
3	2687 to 2779	46.09	28	29.6	0.09	
4	2780 to 2900	50.02	33	32.2	0.02	
5	2901 to 2963	12.27	10	7.9	0.56	
6	2964 to 3046	9.21	11	5.9	4.41	
7	3047 to 3136	5.40	5	3.5	0.64	
8	3137 to 3296	5.74	5	3.7	0.46	
Totals		200.55	129	129.0	10.74	
degrees of freedom: 7			**sig. 0.05:**	14.07	**Not Significant**	

Table A17. Sites Overall Compared with Slope Classes, West Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	69.33	399	389.2	0.25	
2	0.5 to 5	33.34	126	187.2	20.01	-
3	5.1 to 10	49.70	285	279.0	0.13	
4	10.1 to 20	59.71	376	335.2	4.97	+
5	20.1 to 30	32.31	180	181.4	0.00	
6	30.1 to 40	15.91	95	89.3	0.36	
7	>40	6.72	38	37.7	0.00	
Totals		267.02	1499	1499.0	25.72	
degrees of freedom:		6	**sig. 0.05:**	12.59		

Table A18. Sites with Stone Rings Compared with Slope Classes, West Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	48.08	255	223.8	4.35	+
2	0.5 to 5	20.82	58	96.9	15.62	-
3	5.1 to 10	41.61	172	193.7	2.43	-
4	10.1 to 20	53.62	288	249.6	5.91	+
5	20.1 to 30	29.51	138	137.4	0.00	
6	30.1 to 40	14.88	68	68.9	0.01	
7	>40	6.33	21	29.5	2.45	-
Totals		214.85	1000	999.8	30.77	
degrees of freedom:		6	**sig. 0.05:**	12.59		

Table A19. Sites with Lithic Scatters Compared with Slope Classes, West Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	69.33	226	222.0	0.07	
2	0.5 to 5	33.34	76	106.8	8.88	-
3	5.1 to 10	49.70	170	159.1	0.75	
4	10.1 to 20	59.71	210	191.2	1.85	
5	20.1 to 30	32.31	96	103.5	0.54	
6	30.1 to 40	15.91	50	50.9	0.02	
7	>40	6.72	27	21.5	1.41	
Totals		267.02	855	855.0	13.52	
degrees of freedom:		6	**sig. 0.05:**	12.59		

Table A20. Sites with FCR Compared with Slope Classes, West Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	69.33	120	102.8	2.88	+
2	0.5 to 5	33.34	53	49.4	0.26	
3	5.1 to 10	49.70	88	73.7	2.77	+
4	10.1 to 20	59.71	87	88.6	0.03	
5	20.1 to 30	32.31	25	47.9	10.95	-
6	30.1 to 40	15.91	17	23.6	1.85	
7	>40	6.72	6	10.0	1.60	
Totals		267.02	396	396.0	20.34	
degrees of freedom:	6		**sig. 0.05:**	12.59		

Table A21. Sites with Hearth Compared with Slope Classes, West Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	69.33	51	51.9	0.01	
2	0.5 to 5	33.34	11	25.0	7.84	-
3	5.1 to 10	49.70	52	37.2	5.89	+
4	10.1 to 20	59.71	50	44.7	0.63	
5	20.1 to 30	32.31	21	24.2	0.42	
6	30.1 to 40	15.91	11	11.9	0.07	
7	>40	6.72	4	5.0	0.20	
Totals		267.02	200	199.9	15.06	
degrees of freedom:	6		**sig. 0.05:**	12.59		

Table A22. Sites Overall Compared with Slope Classes, East Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	60.68	419	415.8	0.02	
2	0.5 to 5	23.56	111	161.4	15.74	-
3	5.1 to 10	45.05	297	308.7	0.44	
4	10.1 to 20	45.98	371	315.0	9.96	+
5	20.1 to 30	16.39	114	112.1	0.03	
6	30.1 to 40	6.16	50	42.2	1.44	+
7	>40	2.71	12	18.6	2.34	-
Totals		200.53	1374	1373.8	29.97	
degrees of freedom:	6		**sig. 0.05:**	12.59		

Table A23. Sites with Stone Rings Compared with Slope Classes, East Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	60.68	171	213.6	8.50	-
2	0.5 to 5	23.56	29	82.9	35.04	-
3	5.1 to 10	45.05	174	158.6	1.50	
4	10.1 to 20	45.98	237	161.9	34.84	+
5	20.1 to 30	16.39	61	57.7	0.19	
6	30.1 to 40	6.16	25	21.7	0.50	
7	>40	2.71	9	9.5	0.03	
Totals		200.53	706	705.9	80.60	
degrees of freedom:	6		**sig. 0.05:**	12.59		

Table A24. Sites with Lithic Scatters Compared with Slope Classes, East Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	60.68	291	262.7	3.05	+
2	0.5 to 5	23.56	84	102.0	3.18	-
3	5.1 to 10	45.05	180	195.0	1.15	
4	10.1 to 20	45.98	208	199.0	0.41	
5	20.1 to 30	16.39	67	70.9	0.21	
6	30.1 to 40	6.16	33	26.7	1.49	
7	>40	2.71	5	11.7	3.84	-
Totals		200.53	868	868.0	13.33	
degrees of freedom:	6			**sig. 0.05:**	12.59	

Table A25. Sites with FCR Compared with Slope Classes, East Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	60.68	221	183.7	7.57	+
2	0.5 to 5	23.56	66	71.3	0.39	
3	5.1 to 10	45.05	117	136.4	2.76	-
4	10.1 to 20	45.98	128	139.2	0.90	
5	20.1 to 30	16.39	49	49.6	0.01	
6	30.1 to 40	6.16	22	18.6	0.62	
7	>40	2.71	4	8.2	2.15	-
Totals		200.53	607	607.0	14.40	
degrees of freedom:	6			**sig. 0.05:**	12.59	

Table A26. Sites with Hearths Compared with Slope Classes, East Block.

Class	*Degrees*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0	60.68	43	39.0	0.41	
2	0.5 to 5	23.56	9	15.2	2.53	
3	5.1 to 10	45.05	21	29.0	2.21	
4	10.1 to 20	45.98	33	29.6	0.39	
5	20.1 to 30	16.39	15	10.5	1.93	
6	30.1 to 40	6.16	6	4.0	1.00	
7	>40	2.71	2	1.7	0.05	
Totals		200.53	129	129.0	8.52	
degrees of freedom:	6			**sig. 0.05:**	12.59	**Not Significant**

Table A27. Sites Overall Compared with Aspect Classes, West Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Flat	6.17	13	34.6	13.48	-
2	North	22.26	161	124.9	10.43	+
3	Northeast	24.49	175	137.5	10.23	+
4	East	36.80	227	206.6	2.01	+
5	Southeast	37.28	190	209.3	1.78	
6	South	35.17	166	197.4	4.99	-
7	Southwest	34.31	188	192.6	0.11	
8	West	42.97	230	241.2	0.52	
9	Northwest	27.61	149	155.0	0.23	
Totals		267.06	1499	1499.1	43.78	
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A28. Sites with Stone Rings Compared with Aspect Classes, West Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Flat	1.15	0	5.4	5.40	-
2	North	18.48	107	86.0	5.13	+
3	Northeast	20.22	112	94.1	3.40	+
4	East	30.77	173	143.2	6.20	+
5	Southeast	30.27	138	140.9	0.06	
6	South	25.66	89	119.4	7.74	-
7	Southwest	27.57	115	128.3	1.38	
8	West	36.85	167	171.5	0.12	
9	Northwest	23.91	99	111.3	1.36	
Totals		214.88	1000	1000.1	30.79	
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A29. Sites with Lithic Scatters Compared with Aspect Classes, West Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Flat	6.17	12	19.8	3.07	-
2	North	22.26	101	71.3	12.37	+
3	Northeast	24.49	94	78.4	3.10	+
4	East	36.80	110	117.8	0.52	
5	Southeast	37.28	96	119.4	4.59	-
6	South	35.17	108	112.6	0.19	
7	Southwest	34.31	116	109.8	0.35	
8	West	42.97	129	137.6	0.54	
9	Northwest	27.61	89	88.4	0.00	
Totals		267.06	855	855.1	24.73	
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A30. Sites with FCR Compared with Aspect Classes, West Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Flat	6.17	7	9.1	0.48	
2	North	22.26	47	33.0	5.94	
3	Northeast	24.49	45	36.3	2.09	
4	East	36.80	55	54.6	0.00	
5	Southeast	37.28	47	55.3	1.25	
6	South	35.17	53	52.2	0.01	
7	Southwest	34.31	55	50.9	0.33	
8	West	42.97	52	63.7	2.15	
9	Northwest	27.61	35	40.9	0.85	
Totals		267.06	396	396.0	13.10	
degrees of freedom:		8	**sig. 0.05:**	15.51	**Not Significant**	

Table A31. Sites with Hearths Compared with Aspect Classes, West Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	Flat	6.17	5	4.6	0.03	
2	North	22.26	26	16.7	5.18	+
3	Northeast	24.49	16	18.3	0.29	
4	East	36.80	34	27.6	1.48	
5	Southeast	37.28	26	27.9	0.13	
6	South	35.17	17	26.3	3.29	-
7	Southwest	34.31	22	25.7	0.53	
8	West	42.97	34	32.2	0.10	
9	Northwest	27.61	20	20.7	0.02	
Totals		267.06	200	200.0	11.05	
degrees of freedom:		8	**sig. 0.05:**	15.51	**Not Significant**	

Table A32. Sites Overall Compared with Aspect Classes, East Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
2	North	14.39	108	98.7	0.88	
3	Northeast	14.77	107	101.3	0.32	
4	East	30.08	216	206.3	0.46	
5	Southeast	28.64	204	196.4	0.29	
6	South	25.27	163	173.3	0.61	
7	Southwest	30.99	212	212.5	0.00	
8	West	35.03	227	240.2	0.73	
9	Northwest	21.36	138	146.5	0.49	
Totals		200.53	1375	1375.2	3.78	
degrees of freedom:		7	**sig. 0.05:**	14.07	**Not Significant**	

Table A33. Sites with Stone Rings Compared with Aspect Classes, East Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
2	North	14.39	44	50.7	0.89	
3	Northeast	14.77	64	52.0	2.77	+
4	East	30.08	118	105.9	1.38	
5	Southeast	28.64	122	100.8	4.46	+
6	South	25.27	85	89.0	0.18	
7	Southwest	30.99	88	108.8	3.98	-
8	West	35.03	115	123.3	0.56	
9	Northwest	21.36	70	75.2	0.36	
Totals		200.53	706	705.7	14.58	
degrees of freedom:		7	**sig. 0.05:**	14.07		

Table A34. Sites with Lithic Scatters Compared with Aspect Classes, East Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
2	North	14.39	66	62.4	0.21	
3	Northeast	14.77	64	64.0	0.00	
4	East	30.08	119	130.4	1.00	
5	Southeast	28.64	121	124.1	0.07	
6	South	25.27	109	109.5	0.00	
7	Southwest	30.99	154	134.3	2.89	
8	West	35.03	154	151.8	0.03	
9	Northwest	21.36	82	92.6	1.21	
Totals		200.53	869	869.1	5.41	
degrees of freedom:		7	**sig. 0.05:**	14.07	**Not Significant**	

Table A35. Sites with FCR Compared with Aspect Classes, East Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
2	North	14.39	54	43.6	2.48	
3	Northeast	14.77	47	44.7	0.12	
4	East	30.08	87	91.1	0.18	
5	Southeast	28.64	76	86.7	1.32	
6	South	25.27	77	76.5	0.00	
7	Southwest	30.99	103	93.8	0.90	
8	West	35.03	103	106.0	0.08	
9	Northwest	21.36	60	64.7	0.34	
Totals		200.53	607	607.1	5.42	
degrees of freedom:		7	**sig. 0.05:**	14.07	**Not Significant**	

Table A36. Sites with Hearths Compared with Aspect Classes, East Block.

Class	*Aspect*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
2	North	14.39	8	9.3	0.18	
3	Northeast	14.77	12	9.5	0.66	
4	East	30.08	24	19.4	2.23	
5	Southeast	28.64	23	18.4	1.15	
6	South	25.27	8	16.3	4.23	
7	Southwest	30.99	16	19.9	0.76	
8	West	35.03	21	22.5	0.10	
9	Northwest	21.36	17	13.7	0.79	
Totals		200.53	129	129.0	10.10	
degrees of freedom:		7	**sig. 0.05:**	14.07	**Not Significant**	

Table A37. Sites Overall Compared with Permanent Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	48.42	293	272.0	1.62	
2	500-999	52.01	338	292.2	7.18	+
3	1000-1499	53.76	294	302.0	0.21	
4	1500-1999	38.21	173	214.7	8.10	-
5	2000-2499	27.55	146	154.8	0.50	
6	2500-2999	23.80	125	133.7	0.57	
7	3000-3499	14.40	81	80.9	0.00	
8	3500-3999	7.50	42	42.1	0.00	
9	4000+	0.80	5	4.5	0.06	
Totals		266.45	1497	1496.9	18.24	
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A38. Sites with Stone Rings Compared with Permanent Water Sources from Topographic Map, West Block (Non-stony Areas Included)

Class	Distance (m)	Area/Km2	Observed	Expected	Chi-Square	Sign
1	0-499	48.42	155	191.2	6.85	-
2	500-999	52.01	246	205.4	8.03	+
3	1000-1499	53.76	211	212.3	0.01	
4	1500-1999	38.21	127	150.9	3.79	-
5	2000-2499	27.55	97	108.8	1.28	
6	2500-2999	23.80	106	94.0	1.53	
7	3000-3499	14.40	70	56.9	3.02	+
8	3500-3999	7.50	35	29.6	0.99	
9	4000+	0.80	5	3.2	1.01	
Totals		266.45	1052	1052.3	26.51	
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A39. Sites with Stone Rings Compared with Permanent Water Sources from Topographic Map, West Block (Non-stony Areas Excluded)

Class	Distance (m)	Area/Km2	Observed	Expected	Chi-Square	Association
1	0-499	26.86	143	125.3	2.50	+
2	500-999	39.35	225	183.6	9.34	+
3	1000-1499	46.15	202	215.3	0.82	
4	1500-1999	33.18	132	154.8	3.36	-
5	2000-2499	24.95	92	116.4	5.11	-
6	2500-2999	22.65	102	105.7	0.13	
7	3000-3499	13.35	65	62.3	0.12	
8	3500-3999	7.02	35	32.7	0.16	
9	4000+	0.65	3	3.0	0.00	
Totals		214.16	999	999.1	21.54	
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A40. Sites with Lithic Scatters Compared with Permanent Water Sources from Topographic Map, West Block

Class	Distance (m)	Area/Km2	Observed	Expected	Chi-Square	Association
1	0-499	48.42	216	155.0	24.01	+
2	500-999	52.01	179	166.5	0.94	
3	1000-1499	53.76	153	172.1	2.12	-
4	1500-1999	38.21	108	122.3	1.67	
5	2000-2499	27.55	75	88.2	1.98	-
6	2500-2999	23.80	70	76.2	0.50	
7	3000-3499	14.40	37	46.1	1.80	
8	3500-3999	7.50	15	24.0	3.38	-
9	4000+	0.80	0	2.6	2.60	-
Totals		266.45	853	853.0	39.00	
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A41. Sites with FCR Compared with Permanent Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	48.42	142	72.1	67.77	+
2	500-999	52.01	74	77.5	0.16	
3	1000-1499	53.76	59	80.1	5.56	-
4	1500-1999	38.21	46	56.9	2.09	-
5	2000-2499	27.55	24	41.0	7.05	-
6	2500-2999	23.80	29	35.5	1.19	
7	3000-3499	14.40	19	21.5	0.29	
8	3500-3999	7.50	4	11.2	4.63	-
9	4000+	0.80	0	1.2	1.20	
Totals		266.45	397	397.0	89.94	-
degrees of freedom:		8	**sig. 0.05:**	15.51		

Table A42. Sites with Hearths Compared with Permanent Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	48.42	42	36.3	0.90	
2	500-999	52.01	41	39.0	0.10	
3	1000-1499	53.76	40	40.4	0.00	
4	1500-1999	38.21	32	28.7	0.38	
5	2000-2499	27.55	13	20.7	2.86	
6	2500-2999	23.80	20	17.9	0.25	
7	3000-3499	14.40	9	10.8	0.30	
8	3500 +	8.29	3	6.2	1.65	
Totals		266.44	200	200.0	6.44	
degrees of freedom:		7	**sig. 0.05:**	14.07	**Not Significant**	

Table A43. Overall Sites Compared with Permanent Water Sources from Topographic Map, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	22.34	148	152.9	0.16	
2	500-999	15.28	93	104.6	1.29	
3	1000-1499	12.08	84	82.7	0.02	
4	1500-1999	11.55	83	79.0	0.20	
5	2000-2499	11.21	69	76.7	0.77	
6	2500-2999	13.27	88	90.8	0.09	
7	3000-3499	13.05	91	89.3	0.03	
8	3500-3999	12.60	82	86.2	0.21	
9	4000-4499	13.27	89	90.8	0.04	
10	4500-4999	13.69	89	93.7	0.24	
11	5000-5499	14.79	108	101.2	0.46	
12	5500-5999	16.80	135	115.0	3.48	
13	6000-6499	16.01	108	109.6	0.02	
14	6500 +	14.24	103	97.5	0.31	
Totals		200.18	1370	1370.0	7.32	
degrees of freedom:		13	**sig. 0.05:**	22.36	**Not Significant**	

Table A44. Sites with Stone Rings Compared with Permanent Water Sources from Topographic Map, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	22.34	17	78.8	48.47	-
2	500-999	15.28	29	53.9	11.50	-
3	1000-1499	12.08	27	42.6	5.71	-
4	1500-1999	11.55	39	40.7	0.07	
5	2000-2499	11.21	43	39.5	0.31	
6	2500-2999	13.27	45	46.8	0.07	
7	3000-3499	13.05	48	46.0	0.09	
8	3500-3999	12.60	48	44.4	0.36	
9	4000-4499	13.27	67	46.8	8.72	+
10	4500-4999	13.69	62	48.3	3.89	+
11	5000-5499	14.79	67	52.2	4.20	+
12	5500-5999	16.80	77	59.3	5.28	+
13	6000-6499	16.01	68	56.5	2.34	+
14	6500 +	14.24	69	50.2	7.04	+
Totals		200.18	706	706.0	98.05	
degrees of freedom:		13	**sig. 0.05:**	22.36		

Table A45. Sites with Lithic Scatters Compared with Permanent Water Sources from Topographic Map, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	22.34	133	96.6	13.72	+
2	500-999	15.28	63	66.1	0.15	
3	1000-1499	12.08	62	52.3	1.73	
4	1500-1999	11.55	55	50.0	0.50	
5	2000-2499	11.21	46	48.5	0.13	
6	2500-2999	13.27	50	57.4	0.95	
7	3000-3499	13.05	60	56.5	0.22	
8	3500-3999	12.60	44	54.5	2.02	-
9	4000-4499	13.27	41	57.4	4.69	-
10	4500-4999	13.69	35	59.2	9.89	-
11	5000-5499	14.79	62	64.0	0.06	
12	5500-5999	16.80	91	72.7	4.61	+
13	6000-6499	16.01	73	69.3	0.20	
14	6500 +	14.24	51	61.6	1.82	
Totals		200.18	866	866.1	40.69	
degrees of freedom:		13	**sig. 0.05:**	22.36		

Table A46. Sites with FCR Compared with Permanent Water Sources from Topographic Map, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	22.34	120	67.5	40.83	+
2	500-999	15.28	44	46.2	0.10	
3	1000-1499	12.08	47	36.5	3.02	+
4	1500-1999	11.55	35	34.8	0.00	
5	2000-2499	11.21	24	33.9	2.89	-
6	2500-2999	13.27	37	40.1	0.24	
7	3000-3499	13.05	42	39.4	0.17	
8	3500-3999	12.60	29	38.1	2.17	-
9	4000-4499	13.27	22	40.1	8.17	-
10	4500-4999	13.69	24	41.4	7.31	-
11	5000-5499	14.79	36	44.7	1.69	
12	5500-5999	16.80	61	50.8	2.05	+
13	6000-6499	16.01	47	48.4	0.04	
14	6500 +	14.24	37	43.0	0.84	
Totals		200.18	605	604.9	69.52	
degrees of freedom:		13	**sig. 0.05:**	22.36		

Table A47. Sites with Hearths Compared with Permanent Water Sources from Topographic Map, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	22.34	8	14.4	2.84	-
2	500-999	15.28	6	9.8	1.47	
3	1000-1499	12.08	13	7.8	3.47	+
4	1500-1999	11.55	6	7.4	0.26	
5	2000-2499	11.21	5	7.2	0.67	
6	2500-2999	13.27	11	8.6	0.67	
7	3000-3499	13.05	6	8.4	0.69	
8	3500-3999	12.60	10	8.1	0.45	
9	4000-4499	13.27	5	8.6	1.51	
10	4500-4999	13.69	9	8.8	0.00	
11	5000-5499	14.79	12	9.5	0.66	
12	5500-5999	16.80	16	10.8	2.50	+
13	6000-6499	16.01	12	10.3	0.28	
14	6500 +	14.24	10	9.2	0.07	
Totals		200.18	129	128.9	15.54	
degrees of freedom:		13	**sig. 0.05:**	22.36	**Not Significant**	

Table A48. Sites Overall Compared with All Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	151.80	901	853.0	2.70	
2	500-999	69.63	362	391.2	2.18	+
3	1000-1499	21.14	103	118.8	2.10	
4	1500-1999	6.87	40	38.6	0.05	-
5	2000-2499	7.43	47	41.7	0.67	
6	2500-2999	6.99	32	39.3	1.36	
7	3000-3499	2.37	11	13.3	0.40	
8	3500-3999	0.19	1	1.1	0.01	
Totals		266.42	1497	1497.0	9.47	
degrees of freedom:		7	**sig. 0.05:**	14.07	**Not Significant**	

Table A49. Sites with Stone Rings Compared with All Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	111.70	542	521.1	0.84	
2	500-999	60.67	270	283.0	0.60	
3	1000-1499	19.51	77	91.0	2.15	
4	1500-1999	6.56	36	30.6	0.95	
5	2000-2499	6.65	37	31.0	1.16	
6	2500-2999	6.69	28	31.2	0.33	
7	3000-3999	2.38	9	11.1	0.04	
Totals		214.16	999	999.0	6.07	
degrees of freedom:		6	**sig. 0.05:**	12.59	**Not Significant**	

Table A50. Sites with Lithic Scatters Compared with All Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	151.80	565	486.0	12.84	+
2	500-999	69.63	174	222.9	10.73	-
3	1000-1499	21.14	52	67.7	3.64	-
4	1500-1999	6.87	19	22.0	0.41	
5	2000-2499	7.43	18	23.8	1.41	
6	2500-2999	6.99	19	22.4	0.52	
7	3000-3499	2.37	5	7.6	0.89	
8	3500-3999	0.19	1	0.6	0.27	
Totals		266.42	853	853.0	30.71	
degrees of freedom:		7	**sig. 0.05:**	14.07		

Table A51. Sites with FCR Compared with All Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	151.80	287	226.2	16.34	+
2	500-999	69.63	61	103.8	17.65	-
3	1000-1499	21.14	18	31.5	5.79	-
4	1500-1999	6.87	9	10.2	0.14	
5	2000-2499	7.43	9	11.1	0.40	
6	2500-2999	6.99	8	10.4	0.55	
7	3000-3499	2.37	4	3.5	0.07	
8	3500-3999	0.19	1	0.3	1.63	
Totals		266.42	397	397.0	42.57	
degrees of freedom:		7	**sig. 0.05:**	14.07		

Table A52. Sites with Hearths Compared with All Water Sources from Topographic Map, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	151.80	122	114.0	0.56	+
2	500-999	69.63	49	52.3	0.21	-
3	1000-1499	21.14	11	15.9	1.51	-
4	1500-1999	6.87	5	5.2	0.01	
5	2000-2499	7.43	4	5.6	0.46	
6	2500-2999	6.99	6	5.2	0.12	
7	3000-3999	2.56	3	1.9	0.64	
Totals		266.42	200	200.1	3.51	
degrees of freedom:		6	**sig. 0.05:**	12.59	**Not Significant**	

Table A53. Sites Overall Compared with All Water Sources from Topographic Map, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	111.88	785	765.7	0.49	
2	500-999	55.32	349	378.6	2.31	
3	1000-1499	24.51	180	167.7	0.90	
4	1500-1999	7.71	49	52.8	0.27	
5	2000-2499	0.77	7	5.3	0.55	
Totals		200.19	1370	1370.1	4.52	
degrees of freedom:		4	**sig. 0.05:**	9.49	**Not Significant**	

Table A54. Sites with Stone Rings Compared with All Water Sources from Topographic Map, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	111.88	371	394.6	1.41	
2	500-999	55.32	192	195.1	0.05	
3	1000-1499	24.51	111	86.4	7.00	
4	1500-1999	7.71	28	27.2	0.02	
5	2000-2499	0.77	4	2.7	0.63	
Totals		200.19	706	706.0	9.11	
degrees of freedom:		4	**sig. 0.05:**	9.49	**Not Significant**	

Table A55. Sites with Lithic Scatters Compared with All Water Sources from Topographic Map, East Block

Class	Distance (m)	Area/Km2	Observed	Expected	Chi-Square	Association
1	0-499	111.88	514	484.0	1.86	
2	500-999	55.32	206	239.3	4.63	
3	1000-1499	24.51	108	106.0	0.04	
4	1500-1999	7.71	33	33.4	0.00	
5	2000-2499	0.77	5	3.3	0.88	
Totals		200.19	866	866.0	7.41	
degrees of freedom:		4	**sig. 0.05:**	9.49	**Not Significant**	

Table A56. Sites with FCR Compared with All Water Sources from Topographic Map, East Block

Class	Distance (m)	Area/Km2	Observed	Expected	Chi-Square	Association
1	0-499	111.88	378	338.1	4.71	+
2	500-999	55.32	118	167.2	14.48	-
3	1000-1499	24.51	79	74.1	0.32	
4	1500-1999	7.71	25	23.3	0.12	
5	2000-2499	0.77	5	2.3	3.17	+
Totals		200.19	605	605.0	22.80	
degrees of freedom:		4	**sig. 0.05:**	9.49		

Table A57. Sites with Hearths Compared with All Water Sources from Topographic Map, East Block

Class	Distance (m)	Area/Km2	Observed	Expected	Chi-Square	Association
1	0-499	111.88	83	72.1	1.65	
2	500-999	55.32	23	35.6	4.46	
3	1000-1499	24.51	17	15.8	0.09	
4	1500-2499	7.71	6	5.5	0.05	
Totals		199.42	129	129.0	6.25	
degrees of freedom:		3	**sig. 0.05:**	7.82	**Not Significant**	

Table A58. Sites Overall Compared with Landsat Mapped Water Sources, West Block

Class	Distance (m)	Area/Km2	Observed	Expected	Chi-Square	Association
1	0-499	58.93	341	330.8	0.31	
2	500-999	76.35	457	428.5	1.90	
3	1000-1499	66.99	367	376.0	0.22	
4	1500-1999	41.24	207	231.5	2.59	
5	2000-2499	15.06	90	84.5	0.36	
6	2500-2999	6.56	28	36.8	2.10	
7	>3000	1.94	9	10.9	0.33	
Totals		267.07	1499	1499.0	7.81	
degrees of freedom:		6	**sig. 0.05:**	12.59	**Not Significant**	

Table A59. Sites with Stone Rings Compared with Landsat Mapped Water Sources, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	36.32	163	169.0	0.21	
2	500-999	60.55	327	281.8	7.25	+
3	1000-1499	57.80	270	269.0	0.00	
4	1500-1999	37.28	145	173.5	4.68	-
5	2000-2499	14.67	65	68.3	0.16	
6	2500-2999	6.34	22	29.5	1.91	
7	>3000	1.90	8	8.8	0.07	
Totals		214.86	1000	999.9	14.28	
degrees of freedom:		7	**sig. 0.05:**	12.59		

Table A60. Sites with FCR Compared with Landsat Mapped Water Sources, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	58.93	160	87.4	60.31	
2	500-999	76.35	112	113.2	0.01	
3	1000-1499	66.99	74	99.3	6.45	
4	1500-1999	41.24	33	61.1	12.92	
5	2000-2499	15.06	10	22.3	6.78	
6	2500-2999	6.56	6	9.7	1.41	
7	>3000	1.94	1	2.9	1.20	
Totals		267.07	396	395.9	89.08	
degrees of freedom:		6	**sig. 0.05:**	12.59		

Table A61. Sites with Stone Rings Compared with Radar Image Mapped Water Sources, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	53.80	298	245.5	11.23	+
2	500-999	46.84	198	213.8	1.17	
3	1000-1499	39.67	155	181.0	3.73	-
4	1500-1999	24.25	110	110.7	0.00	
5	2000-2499	15.12	61	69.0	0.93	
6	2500-2999	9.46	41	43.2	0.11	
7	>3000	4.34	20	19.8	0.00	
Totals		193.48	883	883.0	17.17	
degrees of freedom:		6	**sig. 0.05:**	12.59		

Table A62. Sites with FCR Compared with Radar Image Mapped Water Sources, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0-499	78.20	133	88.3	22.63	+
2	500-999	57.32	64	64.7	0.01	
3	1000-1499	46.07	23	52.0	16.17	-
4	1500-1999	28.57	26	32.2	1.19	
5	2000-2499	16.08	13	18.1	1.44	
6	2500-2999	10.00	11	11.3	0.01	
7	>3000	4.76	2	5.4	2.14	-
Totals		241.00	272	272.0	43.59	
degrees of freedom:		6	**sig. 0.05:**	12.59		

TableA 63. Sites Overall Compared with Distance from a Drainage, West Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0 to 29	56.87	188	319.2	53.93	-
2	30 to 59	33.28	159	86.8	4.14	-
3	60 to 95	43.28	293	242.9	10.33	+
4	96 to 149	46.86	318	263.0	11.50	+
5	150 to 217	35.86	226	201.3	3.03	+
6	218 to 361	31.46	180	176.6	0.07	
7	362 to 723	15.22	97	85.4	1.56	
8	>732	4.23	38	23.7	8.63	+
Totals		267.06	1499	1398.9	93.19	
degrees of freedom:		7	**sig. 0.05:**	14.07		

TableA64. Sites Overall Compared with Distance from a Drainage, East Block

Class	*Distance (m)*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	0 to 29	31.63	163	216.5	13.22	-
2	30 to 59	22.56	155	154.4	0.00	
3	60 to 89	24.48	186	167.5	2.04	+
4	90 to 127	27.23	215	186.4	4.39	+
5	128 to 173	21.60	146	147.8	0.02	
6	174 to 228	27.78	200	190.1	0.52	
7	229 to 308	24.37	183	166.8	1.57	
8	309 to 751	20.53	122	140.5	2.44	+
Totals		200.18	1370	1370.0	24.20	
degrees of freedom:		7	**sig. 0.05:**	14.07		

Table A65. Sites Overall Compared with Vegetation Classes, West Block

Code	Vegtype	Area/Km2	Observed	Expected	Chi-Square	Association
1	E	48.82	177	277.5	36.40	-
2	SB	64.23	531	365.1	75.38	+
4	SB/ASA	1.72	15	9.8	2.76	+
6	D-F	10.40	68	59.1	1.34	
8	ASA	40.59	267	230.1	5.92	+
9	RS	8.97	33	51.0	6.35	-
10	SA	8.68	33	49.3	5.39	-
11	AAO	26.05	105	148.1	12.54	-
14	JS/E	1.32	6	7.5	0.30	
20	AA	6.21	23	35.3	4.29	-
21	APR	1.96	5	11.1	3.35	-
22	ShS	2.75	8	15.6	3.70	-
25	HR	1.49	6	8.5	0.74	
26	AAO/RS	1.75	8	9.9	0.36	
27	SaS/ShS	6.69	25	38.0	4.45	-
33	SB/AC	7.44	49	42.3	1.06	
Totals		239.06	1359	1358.2	164.33	
degrees of freedom:		15	**sig. 0.05:**	25.00		

Table A66. Sites with Stone Rings Compared with Vegetation Classes, West Block

Code	Vegtype	Area/Km2	Observed	Expected	Chi-Square	Association
1	E	42.77	107	203.9	46.05	-
2	SB	59.62	453	284.2	100.26	+
4	SB/ASA	1.72	11	8.2	0.96	
6	JS	9.74	53	46.4	0.94	
8	ASA	35.16	188	167.6	2.48	+
9	RS	4.56	5	21.7	12.85	-
10	SA	4.91	6	23.4	12.94	-
11	AAO	16.29	30	77.7	29.28	-
14	JS/E	1.27	6	6.1	0.00	
20	AAO	1.85	10	8.8	0.16	
21	APR	0.97	1	4.6	2.82	-
22	ShS	0.81	1	3.9	2.16	-
25	HR	0.74	3	3.5	0.07	
27	Sas/ShS	2.27	2	10.8	7.17	-
33	SB/AC	7.14	29	34.0	0.74	
Totals		189.82	905	904.8	218.88	
degrees of freedom:		14	**sig. 0.05:**	23.68		

Table A67. Sites Overall Compared with Vegetation Classes, East Block

Code	*Vegtype*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	E	3.05	38	21.6	12.45	+
2	SB	58.45	399	414.0	0.54	
6	JS	3.74	36	26.5	3.41	+
8	ASA	20.75	159	147.0	0.98	
9	RS	13.66	92	96.7	0.23	
10	SA	14.74	106	104.4	0.02	
11	AAO	18.21	130	129.0	0.01	
19	PSV	3.00	16	21.2	1.28	
30	DP	1.61	7	11.4	1.7	
35	PR	0.90	8	6.4	0.4	
40	SB.HR.AC	8.59	48	60.8	2.69	-
Totals		146.70	1039	1039.0	23.71	
degrees of freedom:		11	**sig. 0.05:**	19.68		

Table A68. Sites with Stone Rings Compared with Vegetation Classes, East Block

Code	*Vegtype*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	E	3.05	10	9.6	0.02	
2	SB	58.45	270	184.9	39.17	+
6	JS	3.74	24	11.8	12.61	+
8	ASA	20.75	71	65.6	0.44	
9	RS	13.66	16	43.2	17.13	-
10	SA	14.74	5	46.6	37.14	-
11	AAO	18.21	23	57.6	20.78	-
19	PSV	3.00	4	9.5	3.18	
30	DP	1.61	2	5.1	1.88	
35	PR	0.90	2	2.8	0.28	
40	SB.HR.AC	8.59	37	27.2	3.53	
Totals		146.70	464	463.9	136.16	
degrees of freedom:		11	**sig. 0.05:**	19.68		

Table A69. Sites with FCR Compared with Vegetation Classes, West Block

Code	*Vegtype*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	E	3.05	31	11.0	36.36	+
2	SB	58.45	131	211.2	30.45	-
6	JS	3.74	14	13.5	0.02	
8	ASA	20.75	88	75.0	2.25	+
9	RS	13.66	68	49.4	7.00	+
10	SA	14.74	84	53.3	17.68	+
11	AAO	18.21	84	65.8	5.03	+
19	PSV	3.00	12	10.8	0.13	
30	DP	1.61	2	5.8	2.49	-
35	PR	0.90	7	3.3	4.15	+
40	SB/HR/AC	8.59	9	31.0	15.61	-
Totals		146.70	530	530.1	121.17	
degrees of freedom:		11	**sig. 0.05:**	19.68		

Table A70. Sites with Stone Rings Compared with Bison Forage Model, West Block

Class	*Forage*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	90.81	203	429.4	119.37	-
2	buffer	53.04	418	250.8	111.47	+
3	optimal	49.64	294	234.7	14.98	+
Totals		193.49	915	914.9	245.82	
degrees of freedom:	2		**sig. 0.05:**	5.99		

Table A71. Sites with Lithic Scatters Compared with Bison Forage Model, West Block

Class	*Forage*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	129.62	372	423.6	6.29	-
2	buffer	62.17	266	203.2	19.41	
3	optimal	53.63	164	175.3	0.73	+
Totals		245.42	802	802.1	26.43	
degrees of freedom:	2		**sig. 0.05:**	5.99		

Table A72. Sites with FCR Compared with Bison Forage Model, West Block

Class	*Forage*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	129.62	213	195.9	1.49	+
2	buffer	62.17	95	94.0	0.01	
3	optimal	53.63	63	81.1	4.04	-
Totals		245.42	371	371.0	5.54	
degrees of freedom:	2		**sig. 0.05:**	5.99	**Not Significant**	

Table A73. Sites with Stone Rings Compared with Bison Forage Model, East Block

Class	*Forage*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	48.14	88	152.2	32.92	-
2	buffer	52.16	190	164.9	3.82	+
3	optimal	46.49	186	147.0	10.35	+
Totals		146.79	464	464.1	47.09	
degrees of freedom:	2		**sig. 0.05:**	5.99		

Table A74. Sites with Lithic Scatters Compared with Bison Forage Model, East Block

Class	*Forage*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	48.14	322	244.7	24.42	+
2	buffer	52.16	271	265.1	0.13	
3	optimal	46.49	153	236.3	29.36	-
Totals		146.79	746	746.1	53.91	
degrees of freedom:		2	**sig. 0.05:**	5.99		

Table A75. Sites with Stone Rings Compared with Bison Forage Model, East Block

Class	*Forage*	*Area/Km2*	*Observed*	*Expected*	*Chi-Square*	*Association*
1	none	48.14	262	174.1	44.38	+
2	buffer	52.16	182	188.7	0.24	
3	optimal	46.49	87	168.2	39.20	-
Totals		146.79	531	531.0	83.82	
degrees of freedom:		2	**sig. 0.05:**	5.99		

Appendix B: Two-Sample Chi Square Tests

Table B1. Comparison of Soil Stoniness with Classes of Numbers of Rings, West Block.

		Number	**of Rings**	**by Class**			
	Stoniness	1	2	3	4	5	
	Classes	1	2	3 to 4	5 to 9	10 to 106	rings
Observed		10	3	3	4	0	**20**
Expected	1	4.4345	3.5162	4.4345	3.8298	3.785	
DChi²		***6.985***	0.0758	0.464	*0.0076*	**3.785**	
Observed		12	4	5	6	5	**32**
Expected	5	7.0952	5.626	7.0952	6.1277	6.056	
DChi²		***3.3906***	0.4699	0.6187	*0.0027*	0.1841	
Observed		40	41	37	30	31	**179**
Expected	10	39.6887	31.4703	39.6887	34.2766	33.8757	
DChi²		*0.0024*	***2.8857***	0.1821	0.5336	0.2441	
Observed		43	30	49	40	45	**207**
Expected	15	45.897	36.3931	45.897	39.6383	39.1747	
DChi²		0.1829	**1.123**	*0.2098*	*0.0033*	*0.8662*	
Observed		28	29	34	17	28	**136**
Expected	20	30.1545	23.9104	30.1545	26.0426	25.738	
DChi²		0.1539	***1.0834***	*0.4904*	***3.1398***	*0.1988*	
Observed		21	22	26	27	23	**119**
Expected	25	26.3852	20.9216	26.3852	22.7872	22.5207	
DChi²		**1.0991**	*0.0556*	0.0056	*0.7788*	*0.0102*	
Observed		29	22	27	20	24	**122**
Expected	30	27.0504	21.449	27.0504	23.3617	23.0885	
DChi²		*0.1405*	*0.0142*	0.00009	0.4837	*0.036*	
Observed		15	6	17	27	13	**78**
Expected	35-45	17.2945	13.7133	17.2945	14.9362	14.7615	
DChi²		0.3044	**4.3385**	0.005	***9.7439***	0.2102	
Totals		**198**	**157**	**198**	**171**	**169**	**893**

Overall chi-square = 44.50882
DF = 28 P = .0247

Italic text indicates greater than expected. Underlined text indicates fewer than expected.
Bold text indicates a chi square value of greater than one.

Table B2. Comparison of Soil Stoniness with Classes of Numbers of Rings, East Block.

		Number	**of Rings**	**by Class**			
	Stoniness	1	2	3	4	5	
	Classes	1	2	3 to 4	5 to 9	10 to 106	rings
Observed		33	25	26	19	22	**125**
Expected	1	27.8179	21.6763	26.3728	28.1792	20.9538	
DChi²		0.9653	0.5096	0.0053	2.9901	0.0522	
Observed		12	11	20	18	6	**67**
Expected	5	14.9104	11.6185	14.1358	15.104	11.2312	
DChi²		0.5681	0.0329	2.4327	0.5553	2.4366	
Observed		8	4	6	16	8	**42**
Expected	10	9.3468	7.2832	8.8613	9.4682	7.0405	
DChi²		0.1941	1.4801	0.9239	4.5061	0.1308	
Observed		9	8	5	13	9	**44**
Expected	15,20	9.7919	7.6301	9.2832	9.9191	7.3757	
DChi²		0.064	0.0179	1.9763	0.957	0.3577	
Observed		11	11	12	11	12	**57**
Expected	25,30	12.685	9.8844	12.026	12.8497	9.5549	
DChi²		0.2238	0.1259	0.000005	0.2663	0.6257	
Observed		4	1	4	1	1	**11**
Expected	35,40,45	2.448	1.9075	2.3208	2.4798	1.8439	
DChi²		0.984	0.4318	1.215	0.883	0.3863	
Totals		**77**	**60**	**73**	**78**	**58**	**346**

Overall chi-square = 26.29758

DF = 20 P = .1562

Table B3. Comparison of Elevation Classes With Overall Site Area Classes, West Block.

		Site	Area	Classes				
	Elevation	1	2	3	4	5	6	
	Classes	0-100	101-600	601-1800	1801-4500	4501-11000	11001-max	in m^2
Observed	1	8	9	17	9	10	7	**60**
Expected	2450 to	10.792	10.2468	9.6623	9.039	9	11.2597	
DChi²	2505 ft.	0.7224	0.1517	***5.5723***	0.0002	*0.1111*	**1.6115**	
Observed	2	24	25	26	24	25	23	**147**
Expected	2506 to	26.441	25.1045	23.6727	22.1455	22.05	27.5864	
DChi²	2569 ft.	0.2253	0.0004	*0.2288*	*0.1553*	*0.3947*	0.7625	
Observed	3	56	43	43	43	38	41	**264**
Expected	2570 to	47.486	45.0857	42.5143	39.7714	39.6	49.5429	
DChi²	2657 ft.	***1.527***	0.0965	*0.0055*	*0.2621*	0.0646	**1.4731**	
Observed	4	47	23	31	24	35	51	**211**
Expected	2658 to	37.953	36.0344	33.9792	31.787	31.65	39.5968	
DChi²	2716 ft.	***2.157***	**4.7148**	0.2612	**1.9076**	*0.3546*	***3.284***	
Observed	5	83	78	59	50	58	71	**399**
Expected	2717 to	71.768	68.1409	64.2545	60.1091	59.85	74.8773	
DChi²	2829 ft.	***1.758***	***1.4265***	0.4297	**1.7001**	0.0572	0.2008	
Observed	6	28	38	30	35	26	20	**177**
Expected	2830 to	31.837	30.2279	28.5039	26.6649	26.55	33.2162	
DChi²	2897 ft.	0.4624	***1.9983***	*0.0785*	***2.6054***	0.0114	**5.2585**	
Observed	7	25	34	29	37	31	48	**204**
Expected	2898 to	36.694	34.839	32.8519	30.7325	30.6	38.2831	
DChi²	3043 ft.	**3.7265**	0.0202	0.4516	***1.2782***	*0.0052*	***2.4663***	
Observed	8	6	13	13	10	8	28	**78**
Expected	3044 to	14.03	13.3208	12.561	11.7506	11.7	14.6377	
DChi²	3304 ft.	**4.5958**	0.0077	*0.0153*	0.2608	**1.1701**	***12.1981***	
Totals		**277**	**263**	**248**	**232**	**231**	**289**	**1540**

Overall chi-square = 68.22642

DF = 35 P = .0007

Italic text indicates greater than expected. Underlined text indicates fewer than expected. **Bold text** indicates a chi square value of greater than one.

Table B4. Comparison of Elevation Classes With Classes of Numbers of Rings, West Block.

	Elevation Classes	**Number** 1 1	**of Rings** 2 2	**by Class** 3 3 to 4	4 5 to 9	5 10 to 106	rings
Observed	1	9	6	3	1	1	**20**
Expected	2450 to	4.3197	3.4063	4.4339	3.7488	4.0913	
DChi²	2505 ft.	***5.071***	***1.975***	0.4637	**2.0156**	**2.3358**	
Observed	2	13	7	5	3	3	**31**
Expected	2506 to	6.6955	5.2797	6.8725	5.8107	6.3416	
DChi²	2569 ft.	***5.9363***	*0.5605*	0.5102	**1.3595**	**1.7608**	
Observed	3	42	30	34	23	20	**149**
Expected	2570 to	32.1817	25.3768	33.0323	27.9286	30.4805	
DChi²	2657 ft.	***2.9954***	*0.8423*	*0.0283*	0.8698	**3.6036**	
Observed	4	39	19	33	29	35	**155**
Expected	2658 to	33.4776	26.3987	34.3625	29.0533	31.7079	
DChi²	2716 ft.	*0.9109*	**2.0736**	0.054	0.00009	*0.3418*	
Observed	5	62	57	71	61	63	**314**
Expected	2717 to	67.8192	53.4786	69.6118	58.8563	64.2341	
DChi²	2829 ft.	0.4993	*0.2319*	*0.0277*	*0.0781*	0.0237	
Observed	6	25	28	33	30	16	**132**
Expected	2830 to	28.51	22.4814	29.2636	24.7422	27.0029	
DChi²	2897 ft.	0.4321	***1.3546***	*0.4771*	***1.1173***	**4.4833**	
Observed	7	28	24	40	41	50	**183**
Expected	2898 to	39.5252	31.1675	40.5699	34.3016	37.4358	
DChi²	3043 ft.	**3.3607**	**1.6483**	0.008	***1.3081***	***4.2168***	
Observed	8	9	8	14	9	27	**67**
Expected	3044 to	14.471	11.411	14.8535	12.5585	13.706	
DChi²	3304 ft.	**2.0684**	**1.0196**	0.049	**1.0083**	***12.8944***	
Totals		**227**	**179**	**233**	**197**	**215**	**1051**

Overall chi-square = 70.01502

DF = 28 P < 0.0001

Italic text indicates greater than expected. Underlined text indicates fewer than expected.
Bold text indicates a chi square value of greater than one.

Table B5. Comparison of Elevation Classes With Lithic Scatter Area Classes, West Block.

		Site	**Area**	**Classes**			
	Elevation	1	2	3	4	5	
	Classes	0-500	501-2400	2401-7100	7101-19200	19201-max	m²
Observed	1	11	19	12	9	3	**54**
Expected	2450 to	11.585	13.5475	10.3189	9.939	8.6096	
DChi²	2505 ft.	0.0295	***2.1945***	*0.2739*	0.0887	**3.655**	
Observed	2	38	35	27	18	18	**136**
Expected	2506 to	29.177	34.1196	25.9883	25.0317	21.6835	
DChi²	2569 ft.	***2.668***	*0.0227*	*0.0394*	**1.9753**	0.6257	
Observed	3	51	42	32	25	20	**170**
Expected	2570 to	36.471	42.6495	32.4853	31.2896	27.1043	
DChi²	2657 ft.	***5.7877***	0.0099	0.0073	**1.2643**	**1.8621**	
Observed	4	17	22	15	23	23	**100**
Expected	2658 to	21.454	25.0879	19.109	18.4056	15.9437	
DChi²	2716 ft.	0.9246	0.3801	0.8836	***1.1468***	***3.1229***	
Observed	5	37	46	33	31	28	**175**
Expected	2717 to	37.544	43.9039	33.4408	32.2098	27.9015	
DChi²	2829 ft.	0.0079	*0.1001*	0.0058	0.0454	0.0003	
Observed	6	19	26	18	17	8	**88**
Expected	2830 to	18.879	22.0774	16.8159	16.197	14.0305	
DChi²	2897 ft.	*0.0008*	*0.697*	*0.0834*	*0.0398*	**2.592**	
Observed	7	6	19	21	24	24	**94**
Expected	2898 to	20.167	23.5826	17.9625	17.3013	14.9871	
DChi²	3043 ft.	**9.9516**	0.8905	*0.5137*	***2.5936***	***5.4201***	
Observed	8	4	5	5	10	12	**36**
Expected	3044 to	7.7233	9.0317	6.8792	6.626	5.7397	
DChi²	3304 ft.	**1.795**	**1.7997**	0.5134	***1.718***	***6.828***	
Totals		183	214	163	157	136	**853**

Overall chi-square = 62.55793
DF = 28 P = .0002

Italic text indicates greater than expected. Underlined text indicates fewer than expected.
Bold text indicates a chi square value of greater than one.

Table B6. Comparison of Equal Area Classes of Distance from Water Mapped from Radar Image with Classes of Numbers of Rings, West Block.

	Distance Classes	Number 1 1	of Rings 2 2	by Class 3 3 to 4	4 5 to 9	5 10 to 106	rings
Observed	1	33	20	24	29	26	**132**
Expected	0 to	27.3398	21.5016	29.9029	26.0583	27.1974	
DChi²	174 m	***1.1718***	0.1049	**1.1653**	*0.3321*	0.0527	
Observed	2	26	32	41	31	31	**161**
Expected	175 to	33.3463	26.2255	36.4725	31.7832	33.1726	
DChi²	449 m	**1.6184**	***1.2715***	*0.562*	0.0193	0.1423	
Observed	3	40	28	26	16	32	**142**
Expected	450 to	29.411	23.1305	32.1683	28.0324	29.2578	
DChi²	784 m	***3.8124***	***1.0251***	**1.1828**	**5.1647**	*0.257*	
Observed	4	23	17	46	33	46	**165**
Expected	785 to	34.1748	26.877	37.3786	32.5728	33.9968	
DChi²	1189 m	**3.654**	**3.6297**	***1.9885***	*0.0056*	*4.238*	
Observed	5	32	26	34	37	18	**147**
Expected	1190 to	30.4466	23.945	33.301	29.0194	30.288	
DChi²	1739 m	*0.0793*	*0.1764*	*0.0147*	***2.1947***	**4.9853**	
Observed	6	27	19	27	34	30	**137**
Expected	1740 to	28.3754	22.3161	31.0356	27.0453	28.2276	
DChi²	2680 m	0.0667	0.4928	0.5248	***1.7884***	*0.1113*	
Observed	7	11	9	12	3	8	**43**
Expected	>2680	8.9061	7.0043	9.7411	8.4887	8.8598	
DChi²		*0.4923*	*0.5686*	*0.5238*	**3.5489**	0.0834	
Totals		**192**	**151**	**210**	**183**	**191**	**927**

Overall chi-square = 47.04934
DF = 24 P = .0033

Italic text indicates greater than expected. Underlined text indicates fewer than expected.
Bold text indicates a chi square value of greater than one.

Table B7. Comparison of Bison Forage Model With Classes of Numbers of Rings, West Block.

	Forage Model	Number 1 1	of Rings 2 2	by Class 3 3 to 4	4 5 to 9	5 10 to 106	rings
Observed	1	56	39	50	27	30	**202**
Expected	Outside	41.1072	35.5821	45.0853	37.7921	42.4333	
DChi²	Model	***5.3955***	*0.3283*	*0.5357*	**3.0819**	**3.643**	
Observed	2	81	74	83	85	95	**418**
Expected	150 m	85.0635	73.6302	93.2954	78.2035	87.8074	
DChi²	Buffer	0.1941	*0.0019*	**1.1361**	*0.5907*	*0.5892*	
Observed	3	49	48	71	59	67	**294**
Expected	Forage	59.8293	51.7877	65.6193	55.0044	61.7593	
DChi²	Model	**1.9601**	0.277	*0.4412*	*0.2902*	*0.4447*	
Totals		**186**	**161**	**204**	**171**	**192**	**914**

Overall chi-square = 18.90976
DF = 8 P = .0153

Italic text indicates greater than expected. Underlined text indicates fewer than expected. **Bold text** indicates a chi square value of greater than one.

Table B8. Comparison of Bison Forage Model With Classes of Numbers of Rings, East Block.

	Forage Model	Number 1 1	of Rings 2 2	by Class 3 3 to 4	4 5 to 9	5 10 to 106	rings
Observed	1	26	12	20	17	13	**88**
Expected	Outside	20.1034	15.5517	18.9655	18.3966	14.9828	
DChi²	Model	1.7295	0.8111	0.0564	0.106	0.2624	
Observed	2	39	33	34	44	40	**190**
Expected	150 m	43.4052	33.5776	40.9483	39.7198	32.3491	
DChi²	Buffer	0.4471	0.0099	1.179	0.4612	1.8095	
Observed	3	41	37	46	36	26	**186**
Expected	Forage	42.4914	32.8707	40.0862	38.8836	31.6681	
DChi²	Model	0.0523	0.5187	0.8724	0.2139	1.0145	
Totals		**106**	**82**	**100**	**97**	**79**	**464**

Overall chi-square = 9.544133
DF = 8 P = .2985

Italic text indicates greater than expected. Underlined text indicates fewer than expected. **Bold text** indicates a chi square value of greater than one.

Appendix C: Summary of The Positive and Negative Associations Between Variables and Site and Feature Types

Site or Feature Type	Variable	Positive Associations	Negative Associations	Associations With Site Size
All Sites WB	Erosion	Weak Erosion	Strong to Severe Erosion	n/a
	Surficial Geology	Glacial	Alluvial, Colluvial	n/a
	Elevation	Lowest Elev., Near Highest Elev.	Next to lowest Elevation Classes	As elev. increases, so does area of site.
	Slope	10.1 to 20 Degrees Slope	0.5 to 5 Degrees Slope	n/a
	Aspect	North, Northeast, East	Flat, South	n/a
	Dist. From Perm. Water Sources	500 - 999 meters	1500 - 1999 meters	n/a
	Dist. From All Water Sources	Not Statistically Significant		n/a
	Dist From Landsat Image Water	Not Statistically Significant		n/a
	Dist. From Drain.	60 - 217 meters, >732 meters	0 - 59 meters	Smaller closer to drain. larger further back.
	Vegetation	Grasses/Sedges	Rose, Juniper, Greasewood, Brush	n/a

Site or Feature Type	Variable	Positive Associations	Negative Associations	Associations With Site Size
All Sites EB	Erosion	Not Statistically Significant		n/a
	Surficial Geology	Not Statistically Significant		n/a
	Elevation	Mid and Highest Elevations	Lowest Two Elevation Classes	n/a
	Slope	10.1 to 20 Degrees Slope	0.5 to 5, >40 Degrees Slope	n/a
	Aspect	Not Statistically Significant		n/a
	Dist. From Perm. Water Sources	Not Statistically Significant		n/a
	Dist. From All Water Sources	Not Statistically Significant		n/a
	Dist. From Drain.	30 - 89, 309 - 751 meters	0 - 29 meters	n/a
	Vegetation	Rose, Juniper, Povertyweed	Sedge/Grass Mixture	n/a
Sites With Rings WB	Soil Stoniness	0.1 to >50% Surface/Stones	No Stones to 0.1% Surface/Stones	Non-stony areas have fewer number of rings.
	Elevation	Higher Elevations (Classes 4 to 7)	Lower Elevations Excluding Lowest	As elevation increases so does the number of rings
	Slope	Flat, 10.1 to 20 Degrees Slope	0.5 to 10, >40 Degrees Slope	n/a
	Aspect	North Northeast, East	Flat, South	n/a
	Dist. From Perm. Water Sources	0 - 999 meters	1500 - 1999 meters	Not Stat. Significant
	Dist. From All Water Sources	Not Statistically Significant		n/a
	Dist From Landsat Image Water	Not Statistically Significant		n/a
	Dist From Radar Image Water	0 - 499 meters	1000 - 1500 meters	Smaller sites closer to water, larger sites further.
	Vegetation	Grasses, esp. *Stipa* and *Bouteloua*	Rose, Juniper, Greasewood, Brush	n/a
	Bison Forage Mod.	Model Area, esp. 150 Buffer Zone	Area Outside Model and Buffer Zone	Sites largest in model, smallest outside model.

ANALYSIS OF ARCHAEOLOGICAL SETTLEMENT PATTERNS IN GRASSLANDS NATIONAL PARK, SASKATCHEWAN

A Thesis Submitted to the College of

Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Arts

In the Department of Anthropology and Archaeology

University of Saskatchewan

Saskatoon

By

Nathan Paul Friesen

Fall 1998

Site or Feature Type	Variable	Positive Associations	Negative Associations	Associations With Site Size
Sites With Rings EB	Soil Stoniness	None, 3 to >50% Surface/Stones	0.01 to 3% Surface/Stones	Not Stat. Significant
	Elevation	Mid to Highest Elevations	Lowest Two Classes	n/a
	Slope	10.1 to 20 Degrees Slope	Flat, 0.5 to 5 Degrees Slope	n/a
	Aspect	Northeast, Southeast	Southwest	n/a
	Dist. From Perm. Water Sources	4000 - 6499 meters	0 to 1499 meters	n/a
	Dist. From All Water Sources	Not Statistically Significant		n/a
	Vegetation	Grasses, esp. *Stipa* and *Bouteloua*	Rose, Juniper, Greasewood, Brush	n/a
	Bison Forage Mod.	Model Area, 150 Meter Buffer Zone	Area Outside Model and Buffer Zone	Not Stat. Significant
Sites With Lithic Scat WB	Elevation	Lowest Two Classes	Mid Range Elevation (Class 5)	As elevation increases, so does site size.
	Slope	None	0.5 to 5 Degrees Slope	n/a
	Aspect	North, Northeast	Flat, Southeast	n/a
	Dist. From Perm. Water Sources	0 - 499 meters	1000 - 1499, 2000 - 2499, 3500 - 4000 m.	n/a
	Dist. From All Water Sources	0 - 499 meters	500 - 1499 meters	n/a
	Bison Forage Mod.	150 Meter Buffer Zone	Area Outside Model and Buffer Zone	n/a
Sites With Lithic Scat EB	Elevation	Mid Range Elevation	Highest Elevation	n/a
	Slope	Flat	0.5 to 5, >40 Degrees Slope	n/a
	Aspect	Not Statistically Significant		n/a
	Dist. From Perm. Water Sources	0 - 499, 5500 - 5999 Meters	3500 - 4999 Meters	n/a
	Dist. From All Water Sources	Not Statistically Significant		n/a

Site or Feature Type	Variable	Positive Associations	Negative Associations	Associations With Site Size
Sites With FCR, WB	Elevation	Lowest Two Elevation Classes	Three Mid Range Elev. Classes (4-6)	n/a
	Slope	Flat, 5.1 to 10 Degrees Slope	20.1 to 30 Degrees Slope	n/a
	Aspect	Not Statistically Significant		n/a
	Dist. From Perm. Water Sources	0 - 499 Meters (Strong Association)	1000 - 2499, 3500 - 3999 Meters	n/a
	Dist. From All Water Sources	0 - 499 Meters	500 - 1499 Meters	n/a
	Dist From Landsat Image Water	0 - 499 Meters (Strong Association)	1000 - 2499 Meters	n/a
	Dist From Radar Image Water	0 - 499 Meters	1000 - 1499, >3000 Meters	n/a
	Bison Forage Mod.	Not Statistically Significant		n/a
Sites With FCR, EB	Elevation	Lowest Elevation, Highest	Mid Range Elevation Class (4)	n/a
	Slope	Flat	5.1 to 10, >40 Degrees	n/a
	Aspect	Not Statistically Significant		n/a
	Dist. From Perm. Water Sources	0 - 499, 1000 - 1499, 5500 - 5999 m.	2000 - 2499, 3500 - 4999 Meters	n/a
	Dist. From All Water Sources	0 - 499, 2000 - 2499 Meters	499 - 1000 Meters	n/a
	Vegetation	Rose, Juniper, Sage, Some Grasses	Very Grassy, Sedges	n/a
	Bison Forage Mod.	Not Statistically Significant		n/a
Sites With Hearths, WB	Elevation	Highest	Mid-Low Elevation (Class 3)	n/a
	Slope	5.1 to 10 Degrees Slope	0.5 to 5 Degrees Slope	n/a
	Aspect	Not Statistically Significant		n/a
	Dist. From Perm. Water Sources	Not Statistically Significant		n/a
	Dist. From All Water Sources	Not Statistically Significant		n/a

Site or Feature Type	Variable	Positive Associations	Negative Associations	Associations With Site Size
Sites With Hearths, EB	Elevation	Not Statistically Significant		n/a
	Slope	Not Statistically Significant		n/a
	Aspect	Not Statistically Significant		n/a
	Dist. From Perm. Water Sources	Not Statistically Significant		n/a
	Dist. From All Water Sources	Not Statistically Significant		n/a